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INDIANA.

DEPARTMENT

—OF—

GEOLOGY AND NATURAL HISTORY.

SIXTEENTH ANNUAL REPORT.

MAURICE THOMPSON,
State Geologist.

EDITED BY S. S. GORBY.

1888.

TO THE GOVERNOR.

INDIANAPOLIS:
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1889.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT.

December 27, 1888—Received, examined by the Governor and transmitted to the Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

PIERRE GRAY,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana this January 2, 1889.

CHARLES F. GRIFFIN,
Secretary of State.

OFFICE STATE GEOLOGIST,
INDIANAPOLIS, IND., December, 1888.

To HON. ISAAC P. GRAY,
Governor of Indiana:

DEAR SIR: Herewith I submit to you the manuscript of the 16th Report of this Department, with a confident hope that it may be found of great value to the people.

I take pleasure in acknowledging here the cordial aid received from you, and I beg to add that my special thanks are due to all the State officers.

During the past fiscal year there has been no appropriation of funds upon which this Department could draw for its running expenses and the salaries of assistants. Hon. J. A. Lemcke, State Treasurer, has kindly furnished the money, for which disinterested liberality he should have the hearty commendation of the people, and the Legislature should promptly reimburse him.

I am happy to state that, although the Department has been very hard pressed, on account of the immense development of our gas field, and the necessary re arranging, re-labeling and re classifying of the entire museum, over and above the usual work of the survey, I have been able to keep the expenditures within the bounds of the ordinary appropriation of five thousand dollars per annum, which includes the salary of the Chief of the Department. I respectfully submit the report and remain,

Most sincerely yours,

MAURICE THOMPSON.

ASSISTANTS TO THE STATE GEOLOGIST.

W. H. THOMPSON,
CHAS. R. DRYER,
S. S. GORBY.

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PREFACE.

In his introductory paper Prof. Thompson has mentioned some of the difficulties with which this department has had to contend for the past two years, the principal of which were a vast increase in the amount of work necessary to be done and an embarrassing lack of funds for the successful and satisfactory prosecution of the work. In December, 1888, Prof. Thompson, on account of continued bad health, was compelled to resign as State Geologist, and the writer was appointed by Governor Gray to fill the vacancy. Since that time I have been wholly without means to employ assistance of any kind, and have been compelled to pay all the necessary office and traveling expenses out of my own pocket; and at the time that this report goes to press there are no funds in the State Treasury upon which I can draw for supplies of any kind.

The report, as Prof. Thompson states, has been greatly delayed by causes over which the State Geologist had no control whatever. It was ready for the printer about the time that the General Assembly convened, but the great amount of printing required by the legislative committees kept the printers continually employed, so that the work for this department was necessarily laid aside. The printing of the Acts of the General Assembly then followed, after which the reports of the other departments of State, previously begun, had to be completed, all of which tended to delay the completion of this volume.

Since December 1, 1888, I have had no assistance, either in the office or out of it, and my duties have been most laborious and varied. The supervision of the Museum, correspondence and other office work, occasional field work and details of every kind, in fact, every duty pertaining to the Department I have been compelled to perform myself, for the reason that there were no means to employ assistance. Much of my time, therefore, has been devoted to work that should have been performed by an office boy, or other assistant, and much important work that only the State Geologist can do has, in consequence, been neglected.

Accompanying this report is a map showing the various natural gas areas of the State. Very nearly one-seventh of the State produces natural gas in paying quantities, and the outlines of the areas, as shown by the map, mark the limits of the various fields where gas is found in paying quantities at the present time. Future developments may enlarge these fields, or disclose others in other parts of the State.

The report upon natural gas contains statistical and other facts pertaining to the various industries throughout the gas field, up to November,

1888. Since that time developments in the gas areas have been very rapid. New wells are brought in at the rate of one a day, and capital is being invested at the rate of near half a million dollars per month.

In his reports, of which this is the second, Professor Thompson has mainly endeavored to present the practical side of science. The stone, coal, clay, sand, gas and petroleum—substances of commercial value—have received the most attention. The aim has been to advertise the immense mineral wealth of the State to the fullest extent, rather than to collect facts of a purely technical or scientific nature.

Letters from every portion of the Union, and, in fact, from nearly every country in Europe, are continually pouring into this office, containing inquiries pertaining to our coal, stone, kaolin and other clays; our gas, petroleum and other substances, and, as a rule, these letters are from persons who are seeking locations for the investment of capital in manufacturing, mining or quarrying industries. Many letters are received from persons who desire to purchase material for the erection of buildings, or who are seeking clays to be used in the arts, or for other minerals known or supposed to be found in this State.

Many of the inquiries concerning the stone, or other resources of the State, require long, carefully written replies. The information sought is often very important, and yet so general in its nature that it can not be obtained in any one geological report of the State. And even when the desired information may be found in some particular report, the chances are that the volume can not be supplied from this office, for at this time the entire stock of Reports is exhausted, except a limited number of the fifteenth. To get all the information frequently required, one would have to consult the entire set of Indiana Geological Reports (which is very difficult to obtain), as the State so far has been surveyed by counties in detail, without reference to formations. No one of our reports is devoted wholly to the coal measures, or coal-bearing counties. Neither does any one of them treat exclusively of the stone deposits, so that any one interested either in stone or coal, or any other of the rich mineral deposits of the State, must consult the entire set of Reports to get all the facts that have been published concerning the particular subject he is interested in.

A comprehensive report upon the building stones of this State is greatly needed. This should be embraced in a single volume of convenient size, and should include all the facts of interest pertaining to the various kinds of stone found throughout the State. A single report would then supply all the facts that are now contained in the entire set

So, too, with the coal and other mineral deposits of the State. The whole subject should be embraced in a single volume, carefully prepared; and those who are interested in any particular subject could then secure the facts they desire without having to procure an entire set of Reports, at great expense, and then laboriously examine them all to get the desired information.

S. S. GORBY.

INTRODUCTORY.

In presenting to the people of Indiana the Sixteenth Report of the Department of Geology and Natural History, it is necessary to say that the field work for the period considered has been very greatly retarded by circumstances over which the State Geologist has had no control. The museum had to be transported to its rooms in the State House, and all the specimens of the vast collection had to be re-labeled, re-arranged and re-set in the new cases. This involved an amount of work not to be estimated by those unfamiliar with the tedious and difficult nature of the undertaking. Some two hundred thousand articles have been handled four or five times during the process, to say nothing of the labor of comparing and identifying the organic remains that had not been studied previously, or whose labels had been lost in moving or that needed revision. Hitherto the museum had been kept in rooms quite inadequate to its needs, which had prevented the Department from making a proper study and classification of the fossils. Both Professor Cox and Professor Collett had labored under exceedingly discouraging circumstances, and the amount and value of their work is marvelous when we consider the limitations and restrictions to which they were subjected. Indeed it is one of the greatest pleasures of making this report that I can bear testimony to the energy, efficiency and enlightened spirit of the distinguished scholars who have preceded me in this office in which, all along, have existed those hampering and worrying needs which now render effective work almost impossible. To think of carrying on a study and report of the great mineral interests of Indiana, caring for her Museum and advancing the scientific study of her Geology and Natural History on a basis of five thousand dollars a year, all told, is absurd. To-day Indiana is among the foremost States in the Union as regards mineral wealth. A proper knowledge of this, disseminated throughout the reading world, would give a mighty impulse to the industries, the trade and the commerce of the State. It has been the effort of the Department to make the most of every opportunity to give the public early notice of every discovery of any importance touching Mines, Minerals, Natural History or Geology, and to this end the principal newspapers of Indianapolis have been furnished, from time to time, with such statements in connection with the work in the field as were thought to embody facts of general interest to the people.

During the two years which have passed since the last report was issued from this office the number of letters of inquiry received from all over the world has been very large and constantly increasing. Most of these letters have been from persons desiring information regarding the material wealth of the State or touching the advisability of locating mining, quarrying or manufacturing establishments within our borders. Many inquiries, however, have been of a purely scientific nature, whilst others have been upon subjects connected with the waters of our many and valuable mineral wells and springs. A very large number of the letters received from citizens of the State have been connected with agriculture, soils and fertilizers. The want of a proper laboratory for chemical analyses and other practical scientific tests and assays, is constantly felt, and the State should furnish this to the Department at once. It has been impossible to analyze the gas discovered in the rocks of Indiana, and thus a very important work in connection with this report has been passed by. The citizens of our great State certainly should have a place prepared for them where they could be sure of obtaining the fullest explanation of whatever is for the advancement of their material welfare. There is a growing desire for progress, for enlightened methods and for the scientific application of knowledge, and this is notably true of our agricultural people, who are beginning to discover that wealth and happiness depend largely on trained and alert minds. The time was when farmers were inclined to treat science as something impractical, and scientists as mere visionaries or "cranks;" but that has passed in a measure, as our excellent school system has prepared the way for a better view. Many of our farmers are thoughtful, reading men, anxious to learn and zealous in the pursuit of the culture best suited to their surroundings and mode of life. At least seven-tenths of the persons in Indiana making inquiry for our reports are farmers, while a larger part of the remainder are educators or students in our schools. I have found that the science of geology (in connection with botany and kindred biological studies) is occupying a great deal of space in our educational field, with the result of stimulating practical experiment and careful investigation along many lines of thought.

The notion that the chief end of geological study is to collect fossils and classify them should be driven from the mind of every student. Paleontology has its place of practical utility as a sign language by which the rocks impart their secrets to us, and through which we may reach the significance of things otherwise meaningless; but, upon the whole, the discovery of a ledge of good building stone is more to be prized than a mine of crinoids or a hill full of trilobites, pentramites and the rest. The discovery of the potato was of more value to mankind than all the works of Darwin, Huxley, Tyndall and Agassiz combined. Nor is this belittling these great men. It simply means that though one should make plain as day the origin of life it would be as nothing compared with a discovery of cheaper food for the poor and shorter hours of labor for the toilers. Abstract study is for the man and woman of leisure; the concrete is for the busy, earnest worker. The greatest good to the greatest number is a maxim which would force the report of a State Geologist into a practical channel; still the larger part of the literature of even popular science must deal with the technical rather than with the untechnical, and we must depend upon the intelligence of the people to enforce a system of education which shall set the popular thought on a level with enlightened investigation. It is by such means that civilization is broadened and bettered year by year. Steam is mere vapor, viewed by itself, but in an engine it is the master of the age. Science, seen in books, is a dry and unpopular literature, but seen in the electrical machines, in the steam-ships, in the mills, the factories and the mines, it is the very vital center of the progressive civilization of the nineteenth century. Many, perhaps the greater number, of our most useful inventions have been discovered by persons unlearned in the sciences, but in almost every case science has perfected what untaught genius has sketched in the rough. The popular mind has begun to grasp the correlations of theory and practice, and it is becoming easier, day by day, to make headway against the prejudice of ignorance. Still there are people in Indiana who trust to "water-witches" to locate wells, and there are others who turn from the man of science to the man who waves a divining rod when opinion is wanted upon the subject of natural gas. Strangely enough, even the most intelligent people, especially when pressed by the excitement of pending or prospective discovery, will give no heed whatever to the teachings of fact, but will turn and follow blindly the suggestions of chance. Evidence of this has not been wanting in the course of the explorations for natural gas. The State Geologist, the moment that a gas reservoir had been pierced in Indiana, began a rapid survey of the field with a view to establishing its probable outlines, thinking by this means to save the citizens of the State many thousands of dollars. In a short time the department was in possession of facts sufficient to make it reasonably certain that the gas area had a definite limit outside of which it would be useless to expend money in boring; but the "experienced well-borers" were listened to in preference to the State Geologist, with the consequence of empty pockets and dry holes. There can be no doubt that several hundred thousand dollars have already been foolishly spent in sinking wells outside the gas limit in this State, and still the boring goes on. This indiscriminate work, however, has had its value to the State in that it has furnished this department with a knowledge of our rock formations which will be of great importance in the near future, and which could not have been obtained in any other way. Furthermore, the popular excitement touching natural gas discoveries has stimulated study and re-search among our citizens, so that I dare say the people of Indiana have to-day a better practical notion of what geology really is than have the people of any other State in this Union. It is to be hoped that this knowledge will have a wholesome effect in the direction of urging wise and liberal legislation for the dissemination of science.

By far the larger part of the field work of the Department since the issuing of the last report has been devoted to the gas field and to a study of the borings therein. Professor Gorby has had charge of this work over the principal area, and his labors, though greatly interrupted and hindered on account of the necessity of looking after the removing and re-arranging the Museum, have been very thorough and satisfactory, embracing every detail with most interesting results. Necessarily his written report has been curtailed and condensed, as the time which should have been given to it had to be taken up with arduous work in the Museum; but it will be found of practical interest and value to the people, while at the same time it embodies a sketch of all that is known regarding the nature and origin of natural gas with a clear statement of the scientific theories connected therewith. It has been the policy of this Department to give to the Assistant Geologists a free field and a full expression of their views. If the State Geologist, in his own judgment, would modify any of the theories advanced by his able assistants, he does not feel like making these modifications a point of controversy. At best theory is a matter of personal conclusion from an individual point of view, and must be tested by the accompanying facts. The opportunities of the assistants in the field have been ample, and the facts they have gathered have been ably presented. Their opinions are worthy of the very highest consideration, and their statements should be taken as authoritative so far as they go. Professor Gorby is an expert paleontologist, and his labor in the Museum has been invaluable. He has had to handle every specimen in the cabinets, identify every species of the organic remains, label and classify each and arrange all in the cases in due order, while at the same time he has prepared a catalogue of the entire collection. This work has progressed rapidly and is thorough so far as it has gone. Much remains to do, however, before the Museum can be said to be fully arranged. A careful revision of the order and the labeling will be necessary, and all the coal-measure plant-fossils are yet to be classified and labeled. Professor Gorby has been assisted in the Museum by Mr. Callis, whose work has been the cleaning and placing of fossils.

In the field Mr. W. H. Thompson has had charge of most of the geological work in the western division, of which a preliminary partial report is herewith submitted; he has also had charge of the natural gas studies from Frankfort westward. When the survey of the western division shall be completed the report must be one of great interest to the people. The sketch now published is necessarily incomplete in most respects, but in it will be found many features of value, especially the notes on the botany and the ornithology of the Kankakee Valley. It is expected that these notes are the merest beginning of a full report of the flora and fauna of that interesting region. Mr. Thompson is doing his work in connection with the Chief of the department, and it will require at least two more years to complete it, probably more.

The survey of Allen County, and that of Dekalb County, will be comprehensive and adequate. Professor Dryer has shown great energy and thoroughness, and his reports are excellent, especially in the clearness and conciseness of their descriptions. It is by the localization of scientific studies and by the description of the simplest features that the objects of science are differentiated for the popular understanding. There was a time when the public school system had a host of opponents among the people, but it would be a very small group of Indiana's citizens who would openly attack that system to-day. So it is with opposition to the work of this Department; at first it had many bitter enemies who argued that the pittance allowed by law for its maintenance was money thrown away; but to-day all the enlightened intelligence of the State is supporting it. It is clearly seen that although no startling results have been reached by our investigations, we have been able to disseminate gradually a vast amount of useful information which has stimulated the development of the State's material resources and attracted the attention of capital and manufacture in every part of the world. The Department has received many hundreds of letters from abroad, from England, Germany, Austria, France, Italy, Russia, and Sweden, not to mention the smaller European States, asking for information upon a multitude of subjects connected with mining, agriculture and the investment of money in enterprises within our State. These letters have all been answered at length and with carefulness of detail. The coal, the building stones, natural gas, limestone for making lime and cement, and our various deposits of fire clay, kaolin and potter's clay, our iron ores, our beds of pyrites, glass sand, grit stone, marls and chalk beds, as well as our incomparable fossil deposits (sought for cabinet purposes), have attracted very wide attention, and a tremendous impulse has been given to the development of our resources within the past two years. In all the gas area, many of the fortunately located towns have leaped from obscurity to importance, from mere rural villages to manufacturing centers of considerable proportions. Kokomo, Marion, Anderson, Muncie, Noblesville, and many other prosperous towns have shown a wonderful growth in population and wealth. Indianapolis has experienced a revolution in the matter of fuel, and the future alone can tell what prosperity is to result to her people, and to what proportions she is to grow as the greatest inland city in the United States. Along with this material growth educational growth must go apace if we shall reap the full benefit of our civilization, for we certainly have reached that age of the world in which it is more necessary than ever before to keep the equilibrium between the public power and the public conscience. Enlightenment in aristocratic countries flows downward from the heights of society; in our country it must well upward from the great plain of the people; in other words, the commonwealth depends upon popular liberality, morality and wisdom. Give the people knowledge and they will take care of the material interests of the country. It is the duty of the State to maintain free fountains of information in order that while the body of commerce and trade is being developed to its fullest power, there may be no lack of a correlative growth and perfection of the public mind, so that our people may avoid the conditions of the old world civilization, which makes necessary a division of the human race into two opposing and unsympathetic elements, the oppressors and the oppressed. This Department has not been controlled in the interest of mere abstract science, its chief views has been the development of Indiana along all the lines of material prosperity. Every effort has been made to encourage inquiry, experiment, investigation and comparison in the light of the most recent methods of science, but at the same time the larger aim has been to enkindle a popular desire for enlightenment upon the practical application of science to the ordinary pursuits of life. Let me insert here an illustration which should make plain my meaning. The board of county commissioners of a certain county in Indiana found it necessary to erect a public bridge over a considerable stream. The structure required expensive stone abutments. With a view to economy the commissioners ordered these abutments to be built of a certain rock outcropping hard by, and which could be quarried easily. The result was that the abutments crumbled down within two or three years, and new ones had to be built at great expense. Now a little science just here would have been very valuable. The simplest test in the world would have shown the quality of the stone used with a great saving to the taxpayers of the county.

This is but one of a thousand instances that might be cited. Popular enlightenment is the great fountain head of economy, thrift and happiness. Ignorance is arrogance, and this means stupid waste of time, energy and money in order to discover what would be obvious from the first to a trained intelligence. But what has all this to do with Geology and Natural History? some one may inquire. Well, Geology and Natural History cover a consideration of the entire field of native wealth in this State. What is agriculture? It is the culture of field plants for the use of man, and Natural History is the history of these plants. What is soil? In the language of Geology it is one of the rocks, therefore this Department studies soils. Whatever is mined from the earth is a subject of Geological inquiry. Whatever lives on or in the earth is treated of in Natural History. So it will be seen that the Legislature in creating the

Department of Geology and Natural History gave to the people an office from which they should receive a broad flood of information. Have they received it? In answer let me point to the development of the coal fields of the State, to the incomparable building stones now going from Indiana to every city in the Ohio and Mississippi valleys, to the iron ores developed, to the clays manufactured into tiles, pottery and alum, and to the inestimable blessing of natural gas. All these, if not due to geological discovery in the first place, have at least had their value and extent made known to the whole world through the reports of this Department. Nor do the printed volumes contain the tenth part of the information imparted to the people. More than five thousand letters of inquiry have been answered by the Chief of Department and his assistants within the past two years. Aside from the letters coming to the office, the State Geologist has received at his home an average of three letters a day, for a large part of each year, which have called for especial attention, ofttimes involving elaborate discussion of scientific subjects and the writing of long and painstaking answers to important inquiries. By such means the Department has been able to do a very widespread and valuable work for the people. Perhaps the best results of these labors have not appeared in a form to be easily pointed out, but any close observer can not fail to note the recent rapid growth of knowledge in Indiana along the lines indicated by the creators of this office. A continuance of the work will be productive of still greater good.

The Museum is now open to the public and is a center of attraction to which swarms of visitors are drawn every day. The educating effect can scarcely be estimated.

Students of our various institutions come to verify, by the light of organic specimens, the teachings of the text-books; teachers come to make special investigations, while whole classes often come together to make the round of the cabinets. Of course a large number of visitors are attracted by mere curiosity, but even these go away with a broader horizon of thought and with a quickened intelligence.

There is a great demand among the people for the reports of this Department, and nearly all the issues from the first to the fifteenth are exhausted. It has been the purpose of the State Geologist to use great care in the distribution so as to have the books go into the hands of those who would make the very best use of them. Farmers, teachers, ministers, manufacturers, miners, quarrymen, persons of enterprise, men of science, public officials interested in the material progress of their counties and districts, investigators, prospectors, indeed, all persons likely to assist the purposes for which the Department was created have been supplied with the reports, besides the regular quota furnished to the Auditor of each county in the State for judicious distribution. Copies have also been sent to the Geological Department of each State, and to that of each foreign government, as well as to a large number of associations and libraries all over the world. By such means has the work of this Department reached the attention of millions of inquiring minds, with the result of advertising the material wealth and advantages of the State in a way that could scarcely be commanded by any other method. There should be given the Department authority to print and distribute at discretion, within proper financial limits, intermediate reports upon special subjects whenever the public interests call for it. In the case of natural gas, if the State Geologist had been authorized to issue a pamphlet report the information it should have contained would have been of immense value to the people. As it was, the Department was compelled to rely upon the newspapers whose editors kindly offered space for communications giving information to the public. Although a great number of readers could be reached in this way, the result was not what could have been accomplished by a connected and practical intermediate report printed in handy form and distributed free to persons interested in the development of gas wells. The saving to the people upon such a report would have been more than a hundred times its cost.

The catalogue of the Museum will be found very important and useful to students who wish to consult the cabinet, and it is indispensable to the curator. It has been compiled without extra cost to the State, as its construction was a necessary part of the re-arrangement and perfect classification of the specimens. The coal-measure fossils are not all included. Indeed, very few of the plants of the carboniferous age will be found, because the large collection of these has not yet been classified and labeled, although it is temporarily arranged in cabinets and forms a most interesting section of the Museum.

The glossary of words and phrases accompanying this volume, and the compendium of the geology and mineralogy of the State reprinted from the fifteenth report are meant for the use of unlearned people who, without them, would be unable to understand properly certain parts of this report. It must be kept constantly in mind that a work of this kind is for the people first, for the learned experts next. If every person in Indiana were a master of science there would be little need for a geological report. You will find a few so-called scientists who would belittle the efforts to popularize scientific literature, but such men are fossils of the most ancient sort, without value to themselves or to mankind. Popular enlightenment is the only valuable enlightenment in a republic like ours. Educate the people and you educate the State, you fertilize the law, you make legislation upon difficult questions easy for the law-making citizen. I do not entertain respect for the kind of science which requires to be locked away from the masses of the people, nor do I think it adds anything to the dignity of knowledge when it sets itself apart wrapped in a cloak of unnecessary jargon. In this report, wherever it has been possible, the use of obscure phrases or technical terms has been avoided, and where this could not be done every effort has been used to make clear to the popular understanding the substance of what was under consideration.

The lack of a chemical laboratory has been felt seriously, especially in connection with a discussion of the problem of natural gas. Indeed, the department has been hampered and hindered on every side in this connection. Professor Gorby's excellent report would have been very much assisted if it could have included a table of careful analyses of the gas, so that intelligent comparison could have been made; the want of these analyses, however, is not by any means the fault of any branch of the department, but is the necessary result of a meager appropriation and a wholly inadequate equipment of the office for the work expected of it. The State should see to this at once, as there is a constantly growing demand among the people for information which chemical analysis and assays are the only means of supplying.

Notwithstanding the circumstances under which it has been prepared, this report is submitted with full confidence that it contains a great deal of matter valuable and instructive which will be most welcome to the public.

THE DRIFT BEDS OF INDIANA.

CHAPTER I.

INTRODUCTORY.

In making the survey of Indiana it becomes more and more necessary, as the work progresses, to give a great deal of time to a study of the immense drift, or glacial deposits; for these deposits are, from both the scientific and the economical point of view, the most important of all the geological features of the State. The future of agriculture over three-fourths of our area depends, in a great degree, upon popular enlightenment touching the nature of our soils, and the best methods of improving and utilizing their productiveness. In a word, while it is not necessary for the farmer to trouble his mind in the least with technical geology, it is one of the absolute requirements of economic agriculture that he shall have an intelligent comprehension of the habits and demands of the plants he cultivates, and a fair knowledge of the nature and constitution of the soil he tills. A study of our drift deposits will disclose much more, however, than the wealth of soil which has made Indiana one of the greatest States in the Union; but the mineral contents of this immense glacial mass can scarcely have proper recognition until the demands of a rapidly increasing population force a closer scrutiny of its constituent parts. Necessity is more than the mother of invention, she is the enforcer of economy, she is the inspirer of experiment, the originator of improved methods of investigation. Slowly but surely the agencies are at work which will bring to the popular understanding, and within the control of the average man the wealth of economic materials heaped in the drift of Indiana.

In directing the survey of the State, it has been the chief aim to collect and group facts, and nothing has been neglected which could be made to serve this purpose. The great number of borings made all over the State since the examinations for natural gas were begun has given excellent opportunity for securing approximate cross-sections and longitudinal outlines of our drift deposits. With the aid of my able assistants, Prof.

Gorby, Dryer and W. H. Thompson, I have been given every facility to study the facts disclosed by these borings, and to bring together an amount of information hitherto unobtainable touching the extent and nature of the glacial deposits of Indiana.

In my last report (Fifteenth Report of the Department), will be found a full general description of the drift, with the accepted theory of its deposit by glacial agency, therefore it is not deemed necessary to return to that part of the subject at this time. It will be sufficient to point out how fully the borings have confirmed certain opinions I dared to hazard in advance of absolute knowledge. The existence of a grand moraine lying across central Indiana, as sketched in the paper above mentioned (see 15th Report), has been fully demonstrated by subsequent discoveries.

Professor Gorby has collected the facts in connection with the borings, and Mr. W. H. Thompson has continued the topographical and geological examinations of the Western Division, which includes the counties of White, Newton, Jasper, Pulaski, Carroll and Fulton, but a complete report upon these counties can not yet be made, and will have to be carried forward to the next volume. Upon the subject of the drift deposits, however, Mr. Thompson has furnished the Department with a mass of valuable facts which have been arranged and presented in the following chapters along with the results of my own examinations.

Some of the discoveries made in the drift by the borings for gas are peculiarly interesting, notably the existence of intercallated beds of fine white plastic clay in the body of the glacial till. This clay was at first pronounced by eminent authority to be kaolin; but upon examination I found it to be the result of selection and precipitation by water of silica, alumina and lime taken from the drift mass. Some of this clay contained as much as thirty per cent. of lime, while other examples held but a trace of calcareous matter.

An immense deposit of nearly pure white clay was penetrated by the drill at Lebanon, in Boone county. Both above and below this mass the drift till was very thick and compact. At Frankfort I saw evidences of the presence of this formation, but I could not ascertain at what depth the drill reached it or what was its thickness. Chalk, or lime marl, quite identical with that of the deposits described in the Fifteenth Report, is met with all through the body of the drift. At various depths strata of muck, soil, vegetable mold, fragments of wood, and some peaty deposits were passed through by the drill. The first well sunk at Frankfort was abandoned while the drill was in the bed of an ancient lake or pond, now filled with a slush of sand, loamy muck and vegetable remains, which was struck at the depth of about one hundred feet. The total thickness of the drift at Frankfort proved to be from 275 to nearly 300 feet. By reference to the tables of drift-borings in another part of this report the reader may, by the aid of a State map, locate the areas over which the glacial till is of greatest thickness, and the outlines of the vast moraines will become quite plain. The water-beds which afford the supply of water for more than two-thirds of Indiana's population are hermetically sealed basins of sand and gravel, inclosed in impermeable blue clay, commonly called hard-pan. In some of these basins water-gas (carburetted hydrogen) is found in small quantities, apparently generated from masses of vegetable matter shut up in the clay. This gas is very light, and the supply, from the nature of things, is never permanent. Frequently the water from the deeper of these sources flows with great force from the mouth of the drill-pipe, forming a gushing fountain. Usually the water of the flowing wells is impregnated more or less with salts of iron and the carbonate of lime held in suspension. The lime deposits itself in a fine white powder, whilst the iron is precipitated in the form of a red oxide painting whatever the water flows over.

One who has studied the cross-sections of the drift-mass at points where railroad cuttings and stream channels pass through will readily understand the value of the records obtained from our gas wells; but it is greatly to be regretted that so many of the drillers neglected or refused to keep accurate and minute notes during the progress of the boring, especially while the drill was in the clay and other drift deposits. The main object was to reach the Trenton limestone, and the chief thought was of gas. It was hard for the average well-borer to realize that any importance could attach to the materials through which his drill was cleaving its way. Still, by dint of untiring exertion, Professor Gorby succeeded in obtaining carefully verified records in a large majority of cases.

The contour of the drift mass is found to be comparatively regular in a general way along the line of the great moraine lying across central Indiana. Indubitable evidence everywhere exists showing that great local changes have taken place in the surface of this mass since it was deposited, changes which have all tended to level down inequalities and to bury deep under ground objects which once lay on or near the top. In Newton County a driven well at a depth of 70 feet reached vegetable loam in which were found the remains of leaves and plant-twigs. Over this county the drift depth is quite variable, the main body of the deposit lying around a cone of upheaval where the Niagara limestone outcrops with almost vertical strata. Careful study of hundreds of borings shows that the blue clay, known as till or hard-pan, is the only element of the drift which is genuinely persistent. The nature of this clay varies as regards the quantitative relations of its chief elements, and, consequently, its color oscillates between a pale ash-gray and a dark steel-blue, and shows every tint between those extremes. Wherever the mass is dark, soft and plastic it usually contains a large per cent. of silicia and alumina; where it is pale gray and refractory it holds more lime and crumbles readily upon exposure to the atmosphere. Under the microscope the minute particles of the drift clay clearly show that a wide variety of materials has contributed to the mighty grist ground to powder by the glaciers. Bits of coal-measure rock are found side by side with particles of hornblende, graphite, mica, feldspar and quartz, while pebbles of green-stone, polished like jewels, accompany angular fragments of silurian fossils, or worn crystals of calc-spar are side by side with minute fragments of magnetic iron ore. Even traces of gold dust here and there hold out a delusive hope to the ever present fortune hunter.

The soils of the drift present a curious and difficult study. Aside from the vegetable mold varying greatly in thickness, there is a heavy superficial coat of earth covering the drift proper, which presents many anomalous, and, in a great degree, inexplicable features. In some places, over wide areas, this soil has much the character of loess; in others it very closely resembles the residuary soils of Kentucky and Tennessee. Its depth is from one foot to ten feet, and its color is of every shade between black and a light drab, often showing beautiful tints of chocolate, yellow, brown and red. Among farmers it is known as sub-soil, but it is the true soil as distinguished from alluvial and vegetable loams, and upon its nature depends the value of the farming lands of all Northern and Central Indiana. In a general way it may be stated that if the soil is silicious it will be more or less "sour," heavy and wet, unless the silica preponderates in the form of sand, and where it is calcareous it will be light, easily aerated and very productive of corn, wheat, clover and other grasses. As a rule, beech and white oak forests grow on silicious lands, whilst maple, walnut and tulip trees prefer a calcareous soil, whose silica is in the form of sand, and whose deeper subsoil is gravel. Doubtless a great deal of the red and chocolate-colored clays of middle Indiana must be accounted for on the theory of lacustral deposition, but it is difficult to make many of the conditions agree with the requirements of such an assumption. For example, the so-called "modified loess" is most often found covering the highest points of the drift areas in which it occurs. It caps the hills of Montgomery County, south of Crawfordsville, is found on the high lands of Parke and Putnam counties, whilst farther south and east it may be distinguished without trouble in most cases by the trees which best flourish upon it. In almost every case where the deep subsoil is found to be a gravel bed, the soil will be a light brown calcareous loam bearing a heavy per cent. of fine sand. On the other hand, if a drab clay or hard-pan comes near the surface the soil is usually cold, and better suited to meadow than to cultivation in the cereals. Groves of white oak or beech usually cover these areas of "sour" land, but where a deposit of black mucky soil covers the drab clay, the burr-oak forests set in and mark a region, which, if drained, will always prove extremely fertile, as is shown by a large part of Boone County, which was formerly one vast burr-oak swamp, but is now one of the most valuable and beautiful agricultural areas in the State.

Most of the black prairie lands of Indiana are immediately underlaid with blue clay of the drift, but in Tippecanoe County much of the beautiful and incomparably fertile Wea country rests upon a vast bed of gravel and sand.

Superficial drainage is most valuable to the close, cold, silicious soils, especially to those where the blue clay of the drift comes to the surface over wide, almost level areas. Such soils, when once dried and properly aerated, produce enormous crops of timothy grass, making the most desirable hay in our markets. Indeed, in Indiana the one watch-word of our farmers should be: "Drain, drain, drain." No ditch which will bear away water can be laid amiss; every tile added to the drains of our farms is a step toward the age when Indiana shall be as well tilled as the best part of England.

CHAPTER II.

CHANGES AND MODIFICATIONS OF THE DRIFT SINCE ITS DEPOSITION.

If the great drift mass had remained unchanged from the time of its deposition to the present time, and if it could have been possible for us to examine it while it lay just as it was left by the mighty force which heaped it over the rock surface of Indiana, we should be in much better situation than we now are to understand the conditions under which it was transported from its original far northern resting-place and so distributed as to become at length one of the great centers of agriculture and one of the great highways of commerce and civilization. If, as has been claimed, soil and climate control in a large degree the destinies of mankind, it ought to be a very instructive and interesting task to solve, if possible, the conditions which have created the happy combination of a fine climate with a generous and inexhaustible soil. Although we probably never will do this entirely, we may at least reach a practical point of view from which we shall be able to determine all that is necessary to a full masterhood and a perfect enjoyment of our surroundings. Science is worse than worthless if it must be confined to theory and verbal jargon. Of what avail is mere knowledge? Wisdom, which is distilled from knowledge, is the essence of discovery. The study of minerals, fossils, soils and plants is of no value to the people of Indiana if such study does not bring to the popular mind the wisdom of economy, the enlightenment of intelligent masterhood of nature. Such wisdom is of slow growth, but it comes surely to an investigating people. Science sows its seeds, apparently at random, on stones and soil alike, but even in the crevices of the stones the germs find wherewith to sustain a valuable, if slender, life. It can not be said by even the most inveterate "fogy" that in mining, manufacture, transportation and agriculture there has been no access of wisdom from the investigations of science. The more knowledge acquired by the people as a body, the broader the foundation for popular wisdom.

It might appear, at first sight, a work without any practical purpose, for one to begin a study of the drift with a view to arriving at an idea of its form and general appearance immediately after the withdrawal of the great transporting glaciers; but any sincere mind will quickly discover that such an investigation goes before arriving at a competent understanding of the present condition of the subject.

If a glacier, or a succession of glaciers, transported to Indiana the immense mass of matter commonly called drift, there can be no question that an arctic temperature accompanied the glacial visitation, and we must suppose that the whole drift area, upon the retreat of the ice, was left bare, bleak, plantless and desolate, a waste of windy, barren till, traversed by rushing rivers, and dotted with lakes and ponds formed by the melting of the glaciers. I can not see how we can escape the conclusion that plant-life, save that of a boreal flora, was driven far southward of the Ohio River and that for centuries after the recession of the ice the drift area was practically without vegetation and the mighty moraines heaped up in vast billows of clay and bowlders lay exposed to the action of rain, frost, winds and heat, as the seasons passed, with no means of resistance save that of the natural cohesion of the mass. The action of frost and floods must have been very effective under such conditions. No trees, shrubs or grasses with roots to bind and hold the soil and clay together—nothing whatever to counteract the force of freezing and thawing or to check the washing of glacial currents and pouring deluges of rain. Moreover, in the dry seasons, when all the high lands were capped with dust, there was nothing to modify the effects of the winds, whose velocity at times must have been unimaginable. We see great and wonderfully rapid changes going on even now while the art of man and the binding forces of plant life are acting together to prevent them; but how much more rapid and radical must have been the changes under the conditions above suggested!

How long the drift mass lay, bare, bleak and unprotected, subject to all the elements of destruction and change, before the northward migration of plant life began to clothe it with a garment of resistance, can not be conjectured; but, as we now reckon time, it must have been a period too extended for us to have any adequate conception of its duration. Some geologists have attempted to reconcile the presence of the glaciers with a climate almost temperate; but to my mind such a condition is inconceivable. While it is true that glaciers, like those of the Alps, local and inconsiderable as compared with those of Greenland, are found within a temperate area, there can be no doubt that the advent of a body of ice sufficient to plow down granite hills and thrust forth over a large part of North America a mass of till averaging many feet in depth would reduce the temperature of the region affected to arctic severity. In other words, if at present a mighty glacier, hundreds of feet in depth, extended from the region of the Rocky Mountains to the Atlantic coast, and from the latitude of Greenland to that of the Ohio River, its effect would be to change the climate of the southern part of North America from a temperate, sub-tropical and tropical one to a cold, changeable sub-boreal one, and to drive out all plant life save that which can bear the rigid conditions attending such a temperature. How slow would be the return of vegetation to the cold clay region of the drift, after the retreat of the glaciers, may be imagined. At best, under the most favorable conditions of climate and soil, the northward migration of plants is extremely difficult and faltering. But the drift as left by the ice was a clammy mass of clay, without soil, wholly unsuited to the rapid spread of vegetation. We may, therefore, safely assume that for many hundreds, and perhaps thousands, of years after the retreat of the glaciers the drift mass lay exposed to every force of nature without any protection whatever, and underwent every change consequent to such exposure. What would naturally be the result? Speaking generally, we should answer: The result would be a grand leveling process by which the high parts of the drift mass would be reduced by the action of freezing and thawing, the washing of rains and force of winds, and by which the hollows and low places would be filled up apace. Thus old glacial channels would be gradually buried under the materials washed and blown down from the high ridges of moraine matter on either side, lakes and ponds would be filled up by the same process and in the course of centuries a mighty change would take place in the surface configuration of the drift. It matters not how many so-called "periods" of glacial action there may have been, the fact remains that at least there was a final retreat of the ice after which the process of change would have gone on as I have suggested.

As the reduction of the high parts of the great moraines went on the mighty ruts, channels and basins between were gradually obliterated by the filling process, and the whole drift mass took on the comparatively level or broadly undulate surface which now characterizes it. Meantime the well-known assorting power of water and the action of wind in transporting vast bodies of sand were continually at work, so that it is easy to account for many of the gravel beds and bodies of sand and assorted clays found deeply buried in the body of the drift.

At first glance it is surprising to find that ridges of pure sand and conical mounds of clean gravel have withstood the action of frost and water much better than formations of the most refractory hard-pan, but a little consideration explains the apparent contradiction of facts, for water percolates through sand and gravel instead of washing them away, while it must run over the clay and slowly, but surely wear it down. So the action of frost is lost upon the loose particles of sand and gravel, though clay is disintegrated and reduced to dust by it. Hence, it is that the so-called "kames" and "dunes" are the best preserved features left to us of the original drift forms, and they should, therefore, be studied with great care.

One of the most hopeless features of the work now being done by the most enthusiastic and well known students of the drift is the determination to ignore the changes of which I have spoken. No where in the reports, official or private, have geologists appeared to fully comprehend that the drift has not lain, just as it now lies, ever since it was abandoned by the glaciers. If a bit of wood or a wisp of leaves is found ten, or fifty, or a hundred feet below the surface of the ground, they take it for granted beyond cavil, that it was buried there by the glacier, never for a moment considering that the filling up of a hollow by the wash from higher ground may have caused the burial. If a wide area of drift surface is comparatively level now, they conclude that it was just so when the glacier left it. If they can not find in the moraines of Indiana, Ohio and Illinois, every feature of the moraines of the Alps, they shake their heads and say: "There are no moraines." To my mind the study of our glacial area which does not begin with a recognition of the wide and deep changes which were wrought in the drift mass subsequent to the retreat of the ice and prior to the return of vegetation in its present form, is worse than futile. We must understand the fact, and accept it fully to begin with, that the *drift as it is now*, is greatly modified from the *drift as it was when it was fresh from the plow-share of the glacier*. We can not know all the changes nor their extent, but we can and must know that nature has not rested idle for thousands of years in order to leave undisturbed (for the accommodation of scientists) the most easily disturbed of all our geological formations.

It is safe, at least, to take it for granted that the high parts of the drift mass were formerly much higher and the low parts much lower than they now are, and from this fact we may argue that a great many features that now are internal elements of the drift were formerly external ones, and *vice versa.* Where streams have cut deep into the body of the drift it may be observed frequently that the semi-stratified sands and clays are bent or curved, as if somewhat folded by pressure. In many cases this arrangement is due to the washing-down and filling-up process which I have described, each stratum in the series representing the extent of a season's or other cycle's contribution to the lower plane of what it has taken from the higher.

Bearing the above in mind, the student of the drift will be able to distinguish approximately between that part of the mass which is undisturbed and that which is a modification of the original formation. As a rule the highest points will be more likely to be found unchanged in the structure than the lower ones. Of course, the former will be worn down indefinitely, but the material remaining will be in place practically as left by the glacier, while on the latter will be found the washings of centuries of floods, the blowings of centuries of winds and the crumblings of centuries of frosts.

It is then on the highest parts of the drift mass, at points where, from the nature of the surroundings, no great changes could have been effected, that we should look for the true characteristics of the glacial moraine. These points are comparatively few, but when found are extremely interesting Usually they are capped with a boulder field, or they have cones and ridges of gravel and sand to mark a resting place of the glacier's foot at that time when the great ice fields were slowly and with much hesitation retiring into the north. Geologists have, in my opinion, made a great mistake in naming these undisturbed spaces "areas of erosion." They are in fact areas of drift mass remaining, with slight superficial changes, just as the glacier left them, and they usually mark the stranding places of boulder-ladened icebergs and the turning and eddying points of sub-glacial rivers.

On these high areas there are found also many small, undrained basins, the remnants of deep pot-holes which have not been entirely filled up by the leveling process above described. Usually these basins have a subterraneous drain by means of underlying sand or gravel beds, though this is by no means always the case, for I have found them with impervious blue clay bottoms, and they were ponds during all but the dryest seasons.

The changes suggested in the foregoing pages are still going on in a limited way, and it is one of the trials of enlightened agriculture, this battle against the tendency of soil to slip down from the high levels, to wash away, in fact, and leave our very best lands impoverished.

CHAPTER III.

FORCE AND DIRECTION OF THE GLACIERS.

In Indiana the general direction of the glacial movement was a little west of south. There are localities in the State where the *striæ* or sand-marks on the ice-ground rocks run from east to west, and in almost every other horizontal direction; but by careful study these are found to be merely local exceptions to the great general rule. Much confusion and misconception have arisen out of the acceptance (as of conclusive authority) of certain maps and reports of the United States geological survey purporting to define, only in a provisional way, the directions of the glacial *striæ* in the northern part of Indiana. I do not intend personal criticism here, for this would be unjust, and I must not be so understood as to make my words mean any stricture upon the integrity of any person, or upon the general value of any report; but I do wish to say as plainly as words can convey without conveying anything but the friendliest dissent from a theory, that there is no competent evidence whatever of a distinct and separate "second glacial epoch" in Indiana, and that there is no adequate evidence in support of the assumption that the drift of eastern Indiana came from the Lake Erie region, or from any other region much to the eastward of a line drawn north and south through the drift as it now lies. The glacial deposits of Indiana by their conformation, by the materials found in their mass and by the *striæ* underlying them, have come into the State from a direction almost north and south. The internal structure of the drift mass shows conclusively that there have been innumerable local advances and retreats of small lobes or parts of the glaciers, and that there have been many general forward and backward movements of the ice-field as a whole, but there is no evidence pointing with any force to two distinct "glacial epochs." Indeed, the drift deposits conform precisely to the conditions one would naturally expect to find accompanying glacial action of such enormous proportions as that which was able to produce the results at present visible to any casual observer of the area affected.

Glacial *striæ* on the face of rocks known to be in place are not the best evidence of the direction in which the ice-mass *as a whole* may have traveled, and it is injudicious to assume that *striæ* four inches, or four or five feet long, speak conclusively on this point. The exposures of ice-planed rock-surfaces are few and far between in the true drift area. It can not be said that fluid ice alone, of all the fluid substances, flows in a straight line, come what may to hinder or avert. I have seen *striæ* crossing *striæ* on the same rock surface and at almost right angles. Could such testimony be taken as conclusive evidence of two glacial epochs? If so, the later epoch must have been one of very slight power, else its grinding would have obliterated entirely the mere scratches left on the rock by the earlier one! If the first "glacial epoch" was charged with a force that ground down the granite heights of Canada and dashed their till over a vast area, how insignificant must have been the power of the "second glacial epoch" if it could not even obliterate hair-line scratches left by the first on the top of a moderately soft limestone, especially when acting in quite a different direction from that of its predecessor! That the great glaciers came down from their northern fastnesses in billow succeeding billow, a sea of elastic and flexible ice, advancing, retreating, weltering like any other sea, save that all its motions were almost infinitely slow, and rolling on down to its limit, then withdrawing by the same oscillating and faltering process—that all this is true can not be doubted; but this process had nothing in common with two distinct and separate epochs; it was all included in one epoch of drift-making. Doubtless the ice came and went many times, pushing forward and withdrawing partially or wholly from certain areas, until at last it went away forever. There is every evidence in the body of the drift of these oscillations of the great ice pendulum. We can not even conjecture intelligently as to the duration of any advance or withdrawal. From top to bottom of the drift deposits, as shown by the borings for gas and as indicated by every section made by streams, railroads or domestic wells, the mass has a rude system of stratification or lamination in its structure caused by this tide-like motion of the glacial body. Such a motion, the palpitations of which were measured each by centuries, perhaps, could not fail to leave apparently contradictory records in the form of *striæ* on rock-surfaces in different localities.

At Huntington, Marion, Wabash, Kokomo, Logansport, Delphi, Monon and Kentland I have examined *striæ*, and they have been almost exactly parallel in direction, running a little west of south. At Darlington the well-preserved *striæ* are in continuation of this line; but southwest of Crawfordsville I found them running in three directions, southeast, almost east and due south, whilst a little further north on Sugar Creek, and along Black Creek, they conformed exactly with those at Darlington. Near Darlington, however, not far from the bridge of the T. H. & I. R. R. over Sugar Creek, there were *striæ* that appeared to run almost due west. Near Mace (in Montgomery County) there were some obscure marking that indicated a southeastward movement. In Putnam and Parke Counties the *striæ* lie nearly in a north and south line, as they also do near Williamsport, in Warren County, if certain coarse grooves in the sandstone may be accredited. I mention these apparent contradictions in the testimony of the *striæ* to show that isolated cases must not be accepted as even *prima facie* evidence of the *general* direction of the glacial current.

To my mind, the best evidence of the axis of the force which propelled this drift mass lies in the form of the waves of resistance still visible in that mass. In driving a plow across a field the observer notes that the form of the plow-blade and the direction of its movement give form to the waves of resistance offered by the soil. The same is true, in a general way, of any force acting upon a yielding substance; the substance arranges itself in front of the force in a wave of resistance which outlines pretty accurately the direction and nature of that force. Lying across Indiana in practically parallel lines, waves of resistance are clearly traceable in the drift, and these waves all are practically parallel with the southern shore-line of Lake Michigan. The process of leveling described in another chapter has obliterated the superficial outlines of the moraines;

but the gas-well bores have pointed out with reasonable certainty in the mass the direction and extent of those formations.

The surface features of the paleazoic rocks of Indiana were a factor of no small importance in directing and controlling the current of the glacial body. The great disturbance named by Professor Gorby, the *Wabash Arch*, lay directly across the path of the ice, offering a very refractory and persistent barrier to its progress. In surmounting this the glacier was deflected to the westward, the point of one lobe resting at Logansport, while another cut through from Delphi to Lafayette, thus determining the course of the Lower Wabash. This whole rock disturbance in Indiana occurred at the close of the Niagara period, as is shown in another part of this report, and it was only in the lowest parts of its area that any superior formations were deposited. Hence very few fossils whose horizon is above the water-lime are found in the drift immediately south of the Wabash arch.

Wherever the Niagara rocks are exposed at the surface in the area of this disturbance they are apt to show signs of glacial grinding. At Kentland (McKee's quarry) where the strata outcrop almost vertically, the edges of the limestone layers are very plainly marked with grooves and *striæ*. In White County, where there is a heavy outcrop of Devonian shale, the upper stratum of the hard bluish, black rock is finely planed and grooved, the *striæ* running nearly north and south.

The survey has not progressed far enough North to permit me to speak of the moraine provisionally mapped out by Professor T. C. Chamberlain as lying parallel with the south shore of Lake Michigan, and having for points in its line Joliet, Illinois, Valparaiso and Laporte Indiana, and Niles, Michigan, but from some hasty preliminary examinations I am inclined to think that the nature of that formation is not yet properly understood. It appears to me that wind probably has had more to do with certain features of the formation than the glacier had, though there is no doubt as to the morainic character of the main mass.

So far as examinations may be relied upon at this time, it appears that the glacial trough has its greatest depth in the great lakes, and that it gradually shallows southward in a general way; but the Wabash Arch lies across it, midway between Lake Michigan and its southern confine, greatly modifying its form.

From Wabash to Delphi the Wabash up-lift has determined the course of the Wabash River, just as it also determined the form of the drift mass immediately south of it. The river itself is running along the general line of a wide fracture or system of fissures in the Niagara rocks from Wabash to Logansport. At the latter place it has cut through a spur of the Devonian formation, and at Delphi it curves around the base of a curious conical up-lift of the Niagara limestone. To my mind it is plain that the river simply follows the example of the ice current which went before it plowing out the great furrow which we call the Wabash Valley. At present evidence is wanting to prove any theory as to what particular part of the glacial age was devoted to the work of channeling out a groove for Indiana's greatest river, but it would appear that this must have been the first result of the glacier's contact with the low but compact and stubborn knobs of the Wabash Arch. Subsequently, as the ice field grew in weight and power it arose and surmounted this barrier, grinding away its conical peaks and tearing out of its hollows in many places the non-conformable Devonian and Carboniferous rocks.

The drift covers most of the area affected by the Wabash Arch, but the drill has disclosed ample evidence to sustain the main conclusions reached by Professor Gorby and myself as set forth in the Fifteenth Report. In passing over this wide, low, billowy area of upheaval the ice currents must have ground down the highest points of the Niagara rocks, but enough of the inequalities of surface remains to show the nature and extent of the disturbance, which runs entirely across the State, its northern limit passing from some point between Union City and Fort Wayne across in a generally westward course to Kentland. Both North and South of this line strata superior to the Niagara formation appear, abutting against the slopes of the upheaval, showing that the ridge was above water at the time that the Devonian and later rocks were being deposited.

By taking the slopes of the truncated Niagara cone at Kentland I calculated that, if the arch was once perfect, the glacier must have cut away nearly a hundred feet of that upheaval. Nearly as much was removed from the beautifully symmetrical arch at Delphi.

CHAPTER IV.

DEPTH AND STRUCTURE OF THE DRIFT MASS IN INDIANA.

Up to the time when the search for natural gas began in Indiana, we could only conjecture as to the depth of our drift mass. The many wells sunk within the last two years have enabled us to construct approximate cross sections, and to outline the areas of thickest deposit.

Below are given some tables of drift depths from which many useful and instructive facts may be gathered. Table No. 1 contains the thickness of the drift mass at all the chief points along the course of the great central moraine described in the Fifteenth Report of this Department.

TABLE No. 1.

	Depth of Drift.
Kentland	100 feet.
Oxford	385 "
Monticello	205 "
Frankfort	297 "
Noblesville	73 "
Lebanon	300 "
Crawfordsville	140 "
Haughville	123 "
Broad Ripple	55 "
Knightstown	64 "
Winchester	116 "
Shelbyville	78 "
Greenfield	205 "
Rushville	60 "
New Castle	333 "
Union City	98 "

The above table shows that although the western limb of the moraine is somewhat heavier than the eastern one, the mass is remarkably balanced. It must not be overlooked, however, that the gas wells are not always a fair test of the thickness of the drift, as they are sometimes bored in depressions with a view to finding the nearest route to the hard rock below. Carroll county, for instance, is heavily covered with drift, but the gas well at Delphi, owing to the fact that it was sunk at the apex of a fold, shows scarcely any deposit above the Niagara rock. From Indianapolis southward White River breaks through the central point (the apex angle) of the moraine, which here turns northward of an east and west line in both directions, forming across the State a figure in the shape of a rude flattened letter V.

It must not be assumed that the moraine herein referred to is a mere slender ridge, on the contrary it is a wide, slightly rolling plain, covering the whole or parts of many counties, dotted with grand hills and marked here and there with long kame-like ridges composed of sand, gravel, boulders and clay.

The well at Oxford, in Benton county, which shows a drift depth of 385 feet, is bored where the glacial deposit is probably much thinner than it is along the line of the great ridges described by Professor Gorby in his report of his survey of that county. (See Fifteenth Report). I feel quite sure that there are points in both Benton and Newton counties where the drift, if bored through, would be found at least 100 feet thicker than the table shows. Doubtless the same may be said of Clinton, Boone, Montgomery, Marion, Rush and Randolph counties. It is probable that there are places in Indiana where the drift mass is fully 600 or 700 feet thick, though of course this is mere conjecture based upon the facts at hand. One notable conclusion to which an examination of many sections must lead is that the structure of the drift mass is far from uniform, or in other words, that no arrangement of the elements composing the drift is persistent or continuous over any very large area. True, the same features, or practically the same, appear in all the sections, but the order of arrangement differs greatly. What is blue clay in one bore will be sand in another; if we find gravel here we may find a boulder bed yonder at the same horizon, and a mucky deposit in one well takes the place of hard-pan in another near by. One feature always present, but ever alternating with the other elements of the drift mass, is the boulder clay or till always in massive layers with veins of sand, vegetable muck and soil running through at more or less rare intervals, or with intercellated wedges and lenticular beds of water-bearing gravel compressed within the air tight grasp of its substance. In all the bores where the drift is very thick the sections show a great multiplication of these features. The following drift section of a well at Frankfort, where the deposit was 297 feet thick, will serve as an example of arrangement of the more notable features:

WELL No. 1, FRANKFORT.

Soil and modified drift clay	6 feet.
Grayish-blue boulder clay	6 "
Gravel, with thin streaks of clay	33 "
Hard refractory light-blue clay	22 "
Coarse gravel and water	12 "
Close, semi-plastic drab clay	26 "
So-called "quick-sand" with water rising nearly to surface of bore	44 "
Gray "hard-pan"	61 "
Dry sand, fine and white	20 "
Tough blue clay	20 "
Closely packed gravel bed	47 "
Total thickness	297 feet.

There is some doubt as to whether bed-rock was reached in this bore. The drillers persisted in believing that they struck an immense boulder at the depth of 297 feet, and here the drilling ended. The rock may have been a boulder, if so the drift must have been still thicker; but in Well No. 2, drilled a mile east of No. 1, the stratified rock was reached at a depth of 278 feet, as reported to me by the drillers. It will be noted that at Greenfield, on the eastern limb of the moraine, and at Monticello, on the western limb, the drift depth is identical.

The following table will give a fair general average of the greatest thickness of the drift over that part of Indiana north of the Wabash River, and east of the L., N. A. & C. Railroad line:

TABLE No. 2.

	Depth of drift.
Albion	375 feet.
Elkhart	105 "
Rochester	245 "
South Bend	160 "
Warsaw	248 "
North Manchester	274 "

Indeed, I think it quite certain that the general average of depth throughout the whole area above designated, will be found to be over 200 feet.

In Pulaski and Jasper counties there is a considerable area of very shallow drift, the Niagara limestone coming to the surface, or lying just under the soil, in many places.

In the vicinity of Logansport the nature of the drift mass may be observed to great advantage, and from this point eastwardly and westwardly may be traced another great V-shaped terminal moraine caused by the obstruction offered to the glacier by the northern limit of the Wabash arch. The great dividing ridge between the Wabash and the Tippecanoe rivers northward from Logansport, represents a fair average of this immense formation, which has not yet been sufficiently surveyed to be reported upon, but which may be provisionally assumed to occupy a large part of the area between the Wabash and the Kankakee.

Along the Wabash River the stratified rocks outcrop at Lafayette, Delphi, Logansport, Peru, Wabash, Lagro and Huntington. From Delphi to Huntington the evidences of a marked disturbance of the Niagara limestone can be seen at every exposure, whilst the Devonian strata, whenever present, are non-conformably deposited. At Kokomo, nearly southeast of Logansport and about thirty miles distant, the Niagara rock again crops out, whilst between the two points the drift is very deep.

We may take Marion, Kokomo and Delphi as points in a rudely curving line, defining in a rough way nearly the southern border of the apex of the second great terminal moraine in Indiana. The western limb of this formation appears to coalesce with that of the first moraine in Newton and Jasper counties. I say that this appears to be the case, though as yet the survey of the western division is not far enough advanced to make the statement positive.

The borings through the body of the drift show that water is almost sure to be found imprisoned in the sands and gravels between the masses of blue clay; but there are notable exceptions like that at Frankfort, or that at Lebanon. Indeed, there is no widely general rule discoverable governing the order of drift deposit, the occurrence of water, or the position and thickness of any particular element of the confused, tumbled and jumbled mass. Of course, in circumscribed localities certain features are persistent, to a degree, but are subject to sudden and vexatious changes which may disappoint the well-digger and the geologist as well.

It seems to me that comparatively few of the local and superficial features of the drift ought to be referred to any *forward* movement of the glaciers. Naturally, such of these features as remain unchanged should be expected to show the effects of glacial *retreat.* Sand ridges, if the sand be very light and fine, like shore sand, should be referred in many instances to the action of water and wind, whilst gravel cones and banks may nearly always be explained in connection with either the assorting power of water currents, or the melting of stranded icebergs loaded with the materials. On the other hand, the general and comprehensive features of the drift-mass are the true exponents of the active glacial influence, the forward, aggressive force of the great ice field. The outlines of the vast morainic accumulations are, therefore, the boundaries and the limits of forward plunges of the enormous plow-share which ground up the surface of Canada and flung it down upon the worn and polished rock-beds of Indiana.

The internal structure of the glacial deposit shows, by its alternating clays, sands, gravels and boulder beds, its hermetically sealed pockets of water, gas and vegetable remains, found at all horizons indiscriminately, that in every stage of its formation it was subjected to pressure and relaxation, the erosion of water currents and the sudden obliteration of those currents, the formation of soils and the burial of the same in small basins of blue clay, the huddling of great masses of boulders and the drifting together of all manner of mineral fragments. There is no division line to indicate a separation of epochs. On the contrary, the record is continuous, as sea waves are continuous, billow behind billow with connecting troughs between, from the Ohio River northward to Canada. Indeed, no amount of examination could disclose to the most knowing eye any competent evidence disconnecting one "glacial epoch" from another, or defining the limit or bounding the result of any special, separate ice period, save the one vast, almost unimaginable whole of which the part found in Indiana is comparatively small.

The more I study the drift, the more sections I examine, the more facts I gather, the more I am impressed with the evidence of the immense cycle of time which must have revolved during the changes of temperature which effected in our north temperate zone the transformation of a tropical climate to a boreal one, and then softened the latter in turn to the mild and delightful temperature which now prevails. Some scientists have thought themselves competent to reckon the lapse of years from the testimony of the deposits. These geological almanac-makers are men of high fame and of admirable attainments, but their reckonings as to the limits of past ages are of no more value to geological science than a "*Song of the Arval Brothers*" is to the science of veterinary surgery. No man can give the slightest genuine evidence from which it is possible for him to distinguish between one year and a million years as affecting the period of drift-depositing, or of glacial advance or retreat. He has no data for beginning, middle or ending; there is no starting point which has any known date; there is no monument, not even the slightest trace, by which the halting place may be fixed in time. He may, however, study with good result the constitution of the mass, separate its parts and conjecture with reasonable certainty the points, distant or near, from which these have been transported. But a great deal of patient labor yet remains to be done before even the simpler results can be accomplished with any degree of exactness.

Coming now to that part of this subject which will most interest and benefit the larger body of the people of Indiana, it may be said that the agricultural view of the drift demands an analysis of soils and a study of the subject of proper fertilizers. This will be attended to in the future, if this department shall be authorized and empowered to do so At present there is no laboratory in connection with the State Geologist's office, and no appropriation of funds sufficient to enable the department to prepare for the work of making comparative examinations of soils. It is hoped that the Legislature of the State may soon remove this trouble and give the department a chance to do a great work for the benefit of agriculture in Indiana.

CHAPTER V.

MINERALS AND FOSSILS OF THE DRIFT.

Washings and microscopic examinations of the drift clays, from many sections widely separated from one another, have shown that our "till" bears a great variety of minerals, mostly in a finely comminuted state. Silica, lime and alumina are the chief elements, but aside from these in their most common forms, a great number of mineral substances have been discovered, among the most valuable of which are iron ore and chalk-marl, not to mention the tantalizing traces of gold found here and there associated with a black, so-called magnetic sand. The bowlders and pebbles found in all parts of the mass, represent nearly all the igneous and crystalline rocks of Canada, including many forms of granite, gneiss, schist, quartzite, greenstone and pudding-stone, together with specimens of almost every variety of sedimentary or stratified rock to be found in the area north of Indiana. I have prepared a partial list of the drift minerals and also a table of fossils identified from fragments or from entire specimens found in the drift-clays by me and my assistants. Much may be added to these lists in the future as the survey proceeds.

LIST OF MINERALS FOUND IN THE DRIFT:

Aerolites. (Reported, but not seen.)
Agate. (Usually small fragments.)
Allophane. (In connection with chalk.)
Alumina. (Various silicates.)
Anthracite. (Small fragment near surface, and probably not part of drift.)
Asphalt. (Particles of dry bitumen.)
Beryl (?). (Infinitesimal crystal fragments of pale yellowish green.)
Bitumen.
Bloodstone. (Iron ore, hard hematite.)
Bog iron ore.
Bones. (More or less mineralized, mostly the remains of post-pliocene animals.)
Brown ochre.
Brown ores of iron.
Calcareous tufa.
Calc spar.
Carbon. (See graphite.)
Carnelian. (See agate.)
Chalcedony.
Charcoal.
Chert. (See kaolin.)
China clay. (See kaolin.)
Clay. (Varying from coarse hard-pan, bluish or red, to an unctious white kaolin.)
Claystone.
Coal. (Cannel and ordinary bituminous, in small fragments.)
Copper. (Nuggets of various sizes, thickly coated with green oxides.)
Copperas. (See pyrites.)
Feldspar. (Many varieties.)
Ferrous oxides.
Garnet. (Coarse and dull, small fragments.)
Gas. (Light carburetted hydrogen.)
Gneiss.
Gold. (Mere traces.)
Granite.
Graphite.
Greenstone.
Hematite. (Brown.)
Horn-blende.
Iron ores. (Oxides of many varieties.)
Kaolin. (Not kaolin proper, but a fine white silicate of alumina with lime.)

Laumontite. (Supposed to be, adhering to fragment of copper ore.)
Lead. (Galena.)
Lignite, (Buried wood, more or less transformed.)
Limestone. (Of almost every kind.)
Magnesia. (Various silicates, steatite, serpentine, and the carbonate in magnesian limestones.)
Manganese. (Peroxide)
Marble.
Meteorites. (See ærolites.)
Mica. (In schistose rock-fragments and in fine dust.)
Oils. (Traces of petroleum, etc.)
Opal. (Opalized wood.)
Oxides. (Various.)
Pyrites. (Iron and copper.)
Salt. (Traces.)
Silica. (In many forms.)
Zinc-blende.

It will be seen that the above list, although far from complete, covers a wide range of mineral substances. To the most casual observer it is plain that the material composing the drift is far out of place—that it is all transported matter. The bowlders and pebbles of granite, greenstone, gneiss, trap and schist show beyond question that they have been brought into Indiana from Canada. These fragments are rounded and planed, often finely grooved and striated. The limestone bowlders and pebbles, though not as plentiful as those of the igneus or metamorphic kinds, are found throughout the mass; many of them are fossil-bearing with beautifully polished surfaces showing fantastic sections of the shells and other organic remains.

Below is given a partial list of the fossils found in the drift.

Actinocrinus. (Species not certain.)
Aviculopecten. (Species not certain.)
Bellerophon. (Species not certain.)
Calymene. (Species not certain.)
Chætetes. (Species not certain.)
Chondrites. (Impressions in flat limestone.)
Corals. (Of nearly all the silurian and devonian genera.)
Cardaites. (Species uncertain.)
Orthoceras. (Species uncertain.)
Productus. (Species uncertain)
Pleuratomaria. (Species uncertain.)
Rhynchonella. (Species uncertain)
Streptalasma. (Species uncertain.)

Spirifer. (Species uncertain.)
Tentaculites. (Species uncertain.)
Zygospira. (Probably *modesta*.)

Of course this list might be drawn out to a great length if we should include those fossils found imbedded in the limestone fragments of the drift; but, with the exception of *chondrites*, I have named none save those identified from fragments of the specimens found in the blue clay, and most of these have been very small. As yet this microscopic study of the fossil fragments present in the body of the bowlder till has but fairly been begun. I hope in the future to push it much farther.

THE WABASH ARCH.

Careful study of the rock out-crops and of the sections obtained from gas wells in northern Indiana have fully confirmed the report made by Professor Gorby in which evidence of a notable disturbance of the Niagara strata was traced across Indiana far into Illinois.

The name *Wabash Arch* has been objected to by the State Geologist of Ohio, Professor Orton; but we shall keep it, notwithstanding. If men who claim to be devoting their lives to science would trouble themselves less about the jargon of nomenclature and more about gathering facts we should see much better progress in the direction of practical scientific success. We have given the name *Wabash Arch* to the upheaval in Indiana, and *Wabash Arch* it shall be. If Professor Orton take away the name, he must take away the upheaval along with it!

Beginning at Kentland, in Newton County, and passing eastward across Indiana, we shall find at each out-crop of the Niagara rock unmistakable evidence of a disturbance of the strata. It was by the aid of such an exploration that I was led to foresay that few, if any, gas wells would be successful along the immediate line of the Wabash River from Lafayette eastward. I ventured this prediction long before any boring for gas had been done along the river. Of course I knew that there was risk, and, for that matter, there still is risk. Gas may yet be found in vast quantities just where I have said it would not be found; still I adhere to my forecast, because there is every reason upon which to base it. Gas is very likely to escape through rock whose strata are broken and the break un covered to the open air. This condition I found at intervals all along the Wabash, and Professor Gorby verified what I had discovered, as shown in his excellent sketch published in the 15th report of this Department. In one matter I was mistaken. I took it for granted that, because the Wabash River appeared to be running, as it actually is running, in an irregular rift in the Niagara rock, it was, therefore, following pretty nearly the summit of the anticline. The facts have since shown that the disturbance is very broad and of a billowy, broken, irregular form, straggling widely across the State in a direction from southeast to northwest in a general way.

That this upheaval took place at the close of the Niagara period, the evidence is conclusive. There is nothing to dispute it, in fact.

Let us review the testimony gathered from all sources. It has been assumed by certain geologists that the arch here discussed is confined to the Trenton formation, or, rather, that it occurred at the close of the Trenton period. Other geologists have insisted upon referring it to the Cincinnati or Hudson River uplift, making it a part of the great arch, so-called, extending from the lakes to Nashville, Tenn. But so far as the Indiana area is concerned, neither of these theories is tenable, if we admit that the Cincinnati arch is confined to the lower silurian formation. In the first place that the Niagara strata are disturbed can not be questioned successfully since they are not found unbroken in any outcrop north of Indianapolis; and, moreover, the gas drillings show that the disturbance is co-extensive with the entire area in Indiana over which the Niagara is the uppermost stratified rock. Were it not for the disturbance evident in the Niagara outcrops, we might assume that the drill showed merely accidental inequalities in the formation, but when these inequalities are considered in connection with the visible cones, arches and faults observable from Kentland to the head-waters of the Wabash, we can not turn away from the inevitable conclusion.

In connection with my assistant, Mr. W. H. Thompson, I have examined all the exposures of stratified rock along the line of the Wabash River, and over the area north of that river, and west of Logansport, with a view to reporting the facts discoverable bearing upon the subject under consideration. Prof. Gorby has carefully re-examined the area east of Logansport to the State line. All the results are included in this paper.

In McKee's quarry, near Kentland, the Niagara strata stand at angles varying between 60° and 88° with the horizon. Indeed, some of them appear to be quite vertical. There is not the slightest evidence of false-bedding here. The rock is gray-blue limestone of coarse grain, and deposited in parallel layers, with thin clayey or marl-like partings. These layers and partings show that the strata are upturned in the form of a cone which has been truncated by the action of the glaciers. The quarrymen take out the stone by a sidewise operation, following the succession of layers by prying them off one after another. It is not first-rate building stone, but has been found good for foundations, cellar walls and the like.

Taken by itself, this abrupt cone of Niagara limestone thrust up in the midst of a prairie, offers a problem of no easy solution; but taken in connection with the condition of the limestone strata along Monon Creek, and with the very similar and far larger cone at Delphi, the truth begins to appear in the form of an extensive and most interesting upheaval of the Niagara rock.

At McKee's quarry the fossils are neither plentiful nor well preserved, but that all those found *imbedded in* the rock are Niagara fossils is beyond question, whilst those appearing in the clay partings between the strata are, as far as they have been identified, are mostly of the Hudson River formation. Prof. Gorby has suggested, and I am inclined to think correctly, that these lower silurian fossils have been thrown up by the action of gas or water. Evidently they are not in place, because the compact limestone on either side is Upper Silurian.

It has come to be a hobby with geologists that no admission must be made in favor of cataclysms or violent and sudden operations of nature; and yet, within the memory of men now living there has been a breaking and sinking of the crust of the earth in the Mississippi Valley by which the whole face of a large area of country was strangely modified and changed. The earthquake of 1811 was as sudden, almost, as a lightning stroke, or, rather, a series of lightning strokes, and its mighty work was done with all the energy and appalling force of a furious giant. The effects are still visible, and will be probably for all time. Still, if I should say that the upheaval, or rather the disturbance of the Niagara rocks in Indiana, is the result of another just such cataclysmal generation of force as that which wrought the earthquake effects of 1811, there are geologists who would shake their heads and say: "But, my dear sir, there were no sudden upheavals. All the disturbances of the olden time were of slow progression, the effect of centuries and centuries of imperceptible movement. It is impossible, sir, that a chain of mountains should have been thrust up by the impulse of a sudden and irresistible accumulation of pressure, or by a sudden giving way of the earth's crust under a pressure it was no longer able to bear. Don't talk about cataclysms, we have abolished them." Nevertheless, I will talk about ancient earthquakes whose effects were far greater than those of 1811.

That these cones of upheaval in Indiana have been cast up by the sudden crushing of the earth's crust is by no means impossible or improbable. An examination of the texture and fiber of the limestones of these cones will show that at the time of the disturbance they were in some places still in a condition sufficiently plastic to bend and to receive various impressions, and to take on great changes of shape without crushing, while at other places they were broken into small angular fragments, or parted by irregular but persistent cracks and fissures from top to bottom, so far as we can observe.

At McKee's quarry the cone-in-cone structure produced by points of pressure from below, are everywhere to be seen. The force causing these beautiful rosettes in the fiber of the stone has acted in a line exactly perpendicular to the original plane of deposit, showing that the strata were once horizontal, and have since assumed their distorted forms. The fossils, excepting those found in the clay partings, are more or less flattened, indented, twisted and elongated by pressure, showing plainly that they have been subjected to unusual conditions since their deposition.

The strata of the formation at McKee's quarry are not loosely tumbled up, but are set against one another in a compact series, welded together, so to say, by the cement of the clay partings (almost as thin as paper in many places), which usually adheres to the surfaces of the stones when quarried.

The whole rock mass has the appearance of having been subjected to a squeezing process at the same time that it was being thrust upward by an expansive force from below. The arrangement of the structural elements of the rock shows the combined effects of these two agencies: compression from the side and perpendicular thrust from below. All around this area of upheaval the drift is quite deep, more than 100 feet at some points not three miles away, and yet the apex of the cone of rock outcrop on McKee's farm is probably the highest point in Newton county. In every direction the rock surface falls rapidly, and the Devonian shales and limestone are found deposited hard by in an undisturbed condition non-conformably to the Niagara strata. Only a few miles away the subcarboniferous rocks appear horizontally deposited.

Passing eastward to Monon, in White County, and taking a careful survey of the Niagara limestones outcropping along the streams, Mr. W. H. Thompson and myself collected the following facts in addition to those reported by Professor Gorby.

The drift is very thin, and often entirely absent in the little valley of the Monon. During high water the stream lays bare the surface of the underlying limestone, disclosing a most interesting subject for study. The rock is broken into very small angular fragments throughout its substance, as far down as any quarry has been sunk, but the fragments are all in place, separated from one another by fissures running at every possible angle with one another. The surface of the rock-mass is beautifully planed and striæted.

At one place we measured *striæ* that were perfectly straight and parallel for more than thirty feet. Their course was about eight degrees west of south without any correction for magnetic variation. Every thing shows that the cracking and crushing of the Niagara limestone antedates the ice period, for the *striæ* in crossing the fissures show that the force which did the scratching at the same time dragged forward small particles and filled up the cavities or cracks. In some places where the rents or fissures are from six inches to eighteen inches wide; they are filled with drift clay, in which have been found nuggets of copper and other specimens of Lake superior formations. I could not find any evidence whatever of any fissure having been filled with recently assorted matter, which would be the case at some exposed points if the disturbance itself were of recent date.

North of the Monon Creek the Niagara rocks dip northward at the rate of from twenty to thirty degrees, which would appear to indicate a cone in this region not unlike that at Kentland in general form, but much flatter on account of its slighter inclines.

Near Monticello, in the bank of the Tippecanoe River, there is a massive exposure of the bituminous shales of the Devonian formation, which shows no evidence of disturbance. But in the first gas well at Monticello the Devonian (Corniferous) limestone was the uppermost stratified rock, and it lay under a mass of drift 205 feet thick, as reported by the parties boring it. Now, the surface altitude of Monticello above sea-level is 672 feet; take from this the depth of drift, 205 feet, and we have 467 feet as the altitude of the top of the *Corniferous limestone,* while at Francisville, a few miles distant, the altitude of the top of the *Niagara limestone* is 680 feet. The thickness of the Corniferous limestone at Monticello is about 48 feet. Subtract this from 467=419, the altitude of the surface of the Niagara limestone. This gives a difference of 216 feet in the level of the Niagara limestone between Francisville and Monticello. The black Devonian slate or shale is from 60 to 80 feet thick at the river bank near the Norway mills. Near the point where the Monon flows into the Tippecanoe is an outcrop of Corniferous limestone showing no evidence of disturbance. Thus the Monon Creek flows down from its source on the heights of a Niagara upheaval and joins the Tippecanoe in a Devonian valley. This of itself would be very strong and very competent evidence of an upheaval of the Niagara formation.

Passing eastward into Carroll County, we find the city of Delphi occupying the truncated apex of a cone very similar to the one near Kentland, but far more extensive. Here the strata of the Niagara limestone "stand on edge" at angles indicating an arch of from 45 to 50 degrees, measured by a chord of about two miles. In the bluffs of a deep ravine near the northeastern limit of the city a section of a part of this arch is exposed, affording a fine study of its formation. Hard by in the bluffs of Deer Creek are massive exposures of the Devonian shales deposited horizontally without any evidence of disturbance.

Taking the angle of ascent at opposing points in the Niagara arch at Delphi, and calculating the apex therefrom, I found that the highest point of the cone would have an altitude of about 860 feet above sea level, which would place it nearly exactly on a level with the surface of the Niagara limestone in the Fairmount gas well No. 1, and, indeed, on a fair average with many of the higher points of the gas-area northeast of Indianapolis. The following table will show the altitude in feet above sea-level of the upper surface of the Niagara limestone at some of the highest points in the gas field of Indiana:

New Castle	812
Fairmount	870 and 858
Jonesboro	678
Summitville	796
Marion	752 and 741
Farmland	982
Winchester	960
Rushville	884
Shelbyville	698
Francisville	680
Peru	621
Kokomo	778
Broad Ripple	672
Dunkirk	909
Noblesville	685
Greenfield	726
Anderson	776
Frankfort	563
Hartford City	813
Montpelier	836

This table, when compared with another given below, will show that the Niagara rock, when reported upon by the drill, discloses quite as uneven a surface as does the famous Trenton about whose "*anticlines*" and "*synclines*" so much has been written of late.

TABLE SHOWING ALTITUDE OF TRENTON LIMESTONE.

New Castle	120	feet	above	sea level.
Fairmount	41	"	below	"
Jonesboro	72	"	"	"
Summitville	82	"	"	"
Marion	67	"	"	"
Farmland	55	"	above	"
Winchester	53	"	"	"
Rushville	124	"	"	"
Shelbyville	79	"	below	"
Francisville	200	"	"	"
Peru	218	"	"	"
Kokomo	97	"	"	"
Broad Ripple	109	"	"	"
Dunkirk	14	"	"	"
Noblesville	85	"	"	"
Greenfield	54	"	"	"
Anderson	66	"	above	"
Frankfort	487	"	below	"
Hartford City	40	"	"	"
Montpelier	110	"	"	"

Taking the foregoing tables, a comparison of figures will show the general westward dip of the strata, in both the Trenton and the Niagara rocks. Of course it should be remembered that the Niagara having been exposed to the great glacial forces, must have been worn away greatly in places, but it must also be considered that as a rule the highest points would be most eroded. Viewed with these conditions in mind and remembering the visible surface proofs of an Upper Silurian disturbance, these tables will be found coinciding with the evidence yet to come.

From Delphi, passing along up the Wabash River, we shall find no evidence of any disturbance until we again see the Niagara rock outcropping, which is near Logansport. There the strata are tilted and distorted with the Devonian limestone, non-conformably deposited over it. At Kokomo and Peru we find the Niagara limestones broken and upturned, showing a continuance of the disturbance, and going on to Wabash, Lagro, Huntington, Marion, and Decatur, we find at every outcrop the unmistakable signs that we are still skirting along the northern verge of the Wabash arch.

The following tables will afford some curious facts:

Table of notable extremes in the altitude of the surface of the Niagara limestone, as shown by the drill:

Francisville	647	feet above sea level.
Oxford	3	" " " "
Frankfort	563	" " " "
Noblesville	685	" " " "
Kokomo	778	" " " "
Rushville	884	" " " "
Crawfordsville	81	" " " "
Well No. 1, at Peru	621	" " " "
Well No. 2, at Peru	690	" " " "
Shelbyville	698	" " " "
Valparaiso	443	" " " "
South Bend	245	" " " "
Elkhart	125	" " " "

By the above it will be seen that from Oxford to Francisville, a distance of about thirty-nine miles, there is a rise of 644 feet in the surface of the Niagara limestone. From Crawfordsville to Frankfort, 28 miles, the rise is 482 feet. From South Bend to Elkhart the fall is but 120 feet in about 20 miles, while at Peru there is a difference of 69 feet between two wells. Shelbyville and Rushville are about 20 miles apart, and the Niagara limestone is 186 feet lower at the former place than at the latter. Although the general dip of the strata, when undisturbed, is westward, the Niagara at Kokomo, as shown in the first table, is 26 feet higher than at Marion, which is 30 miles farther east. Taking a section across the State from Decatur to Crawfordsville, we shall have the following:

	Niagara above sea level.
Decatur	768 feet.
Bluffton	786 "
Marion	752 "
Kokomo	778 "
Frankfort	563 "
Crawfordsville	81 "

Or, if we prefer as near an east and west section as possible, take—

Decatur	768
Huntington	738
Peru	621
Monticello	427

Which shows simply a regular dip westward. The truth, in a nut-shell, is that the drill is not to be relied upon for locating slight disturbances of hidden strata. Everything that the drill has shown with regard to the Trenton rock in Indiana may be explained perfectly by either affirming or denying the existence of obscure folds or anticlines in that deep-buried formation, and the same is true of the Niagara rock. In the case of the latter, however, we have auxilliary evidence of the most indubitable kind with which to corroborate the testimony of the drill. Of course, if the Niagara limestone is folded ever so slightly, it follows that the Trenton is folded also, and the only question left to discuss, is whether the disturbance, if there is one, originated at the close of the Niagara period. If the Niagara formation is disturbed and the immediately superior formations are undisturbed, then my point is made, and I am right in saying that the system of low anticlines in Indiana (which is the chief geological feature of our gas field) was formed as late as the close of the Niagara rock making. Furthermore, if this upheaval is a part of the "Cincinnati anticline," the whole great range of disturbance extending from the lakes to Tennessee, and heretofore referred to the close of the Hudson River period, must now be set down as occuring long after the lower Silurian formations were finished, and as late as the period in which the water-lime deposits were being laid down.

Professor Orton, State Geologist of Ohio, whose attainments are of the highest, has noted, without explaining, the fact that gas is rarely found in the Trenton rock under areas where the Niagara limestone is not the surface or uppermost stratified rock. It appears to me that this of itself is very suggestive of a disturbance which has brough the Niagara to the surface. Indeed, in Indiana the highest points above sea-level are areas wherein the Niagara limestone is the uppermost stratified rock, and some of the lowest points are those capped by the Carboniferous deposits. These facts testify of upheaval on a wide scale.

In my opinion, Professor Cox was on the right track when he suggested that the "Cincinnati anticline" is but part of a great continental disturbance. I think this will be the final verdict of science, but the upheaval will be referred to the close of the Niagara period, and not to the age of the Hudson River rocks.

One fact which should be recorded as of value in connection with the peculiar condition of the Niagara limestone along the line of the Wabash River is the difficulty experienced in boring through it. The drill encounters the strata at an angle often as great as 60°, rarely less than 40°, and the tendency to follow the trend of the hard layers is such that the bore is made very irregular. This trouble was encountered in a marked degree at Logansport and Delphi. It is to this tilted and conical condition of the Niagara strata that we owe the wonderful apparent thickness of the limestone at many points, for in boring through a stratum tilted up at an angle of from 45° to 80°, its thickness is apparently much greater than when drilling through it at right angles. Had the conical upheaval near Kentland never been truncated by glacial action, a drilling near its apex would have shown the Niagara limestone to be (apparently) eight or nine hundred feet thick, owing to the acuteness of the bore's angle with the face of the strata.

Although, as I have said, we must not depend too much upon the story that the drill tells, we may, I think, assume that we are now in possession of facts sufficient to warrant the statement following: If the drift were stripped clean off the Niagara rock of the Indiana gas field, we should see a surface composed of hillocks and hollows, long low swells and sharply abrupt, or, perhaps, truncated cones, a surface, indeed, not unlike a sea whose gale-tossed billows had been turned suddenly into limestone. Upon close inspection we should find that most of the higher points, like those exposed at Kentland and Delphi, have been ground down a great deal by the glacial forces. It may be that the theory is true which assumes that the Devonian and Carboniferous deposits once lay over our entire gas area; but I find the evidence all disputing it directly and emphatically. The coal basin of Michigan and the Carboniferous area of Indiana lie on opposite sides of the great Niagara disturbance the axis of which in Indiana has been named the Wabash Arch. For example, taking a starting point in Gibson County, Indiana, and making a sheer section through the strata to the Michigan coal field, we should find the Niagara limestone far below sea level at our starting point, whence it would gradually rise northward to Frankfort or Kokomo. Then, from some point a little south of the Wabash River would begin a descent northward, which soon would carry the strata below sea level again, showing that, in a general way, there is a low broad swell of the Niagara formation crossing Indiana from southeast, or east to west, or northwest, forming a dividing ridge between the coal fields of Michigan and those of

Indiana. A line drawn from Crawfordsville, in Montgomery County, Indiana, to Elkhart, Elkhart County, Indiana, near the Michigan line, would show, in accordance with the gas bores nearest the line, a ridge of Niagara limestone about 400 to 500 feet higher between the extremes than at them. For instance, at Frankfort the Niagara is 563 feet above sea level, while at Crawfordsville it is but 81 feet above, and at Elkhart but 125 above. Take Martinsville, Kokomo and Elkhart, all in Indiana, and we shall find the Niagara rock surface at Kokomo 770 feet higher than at Martinsville, and 653 feet higher than at Elkhart. In fact, any section from south to north across the Wabash Arch will show a like anticlinal arrangement of the Niagara formation, but not a corresponding or equivalent arching of the superior formations. In other words, the Niagara breaks up through the Devonian and carboniferous rocks, in a general way, and wherever the latter exist on the disturbed area they are laid down non-conformably.

Doubtless the glacial forces removed a large part of the Devonian deposits, for the bituminous shales and even the Corniferous limestone formations appear in scrappy, island-like remnants here and there between areas of Niagara limestone, which, wherever exposed, shows the unmistakable grinding of the glaciers over its surface.

From my point of view, with all the facts at present before me, it appears probable that the upheaval, of which the Wabash arch is a part, is connected with a continental disturbance which occurred at the close of the Niagara period or thereabout, and before the rocks of that formation had hardened into stone. That subsidence followed this upheaval, after the rocks had hardened, and the force of this sinking crushed the stones and arched the Niagara formation into local bubbles or cones as we today find it, at the same time creating the fissures in which the Wabash River is now flowing. Of course all the strata below the Niagara are affected by the disturbance, hence the condition of the gas-bearing Trenton limestone which, as shown by the drill, is lifted up in conical and bubble-like folds or knobs all over our gas-area, and these bubbles need only to be pricked by the drill to emit their long-imprisoned treasures of inflammable matter.

As yet no lasting, high-pressure supply of gas has been found under an area where the Niagara limestone is badly broken. This appears to me strong proof of the fact that where these breaks occur they extend down to the Trenton, and hence have permitted the gas to escape. The Wabash River marks a series of breaks in the Niagara limestone from Huntington, or eastward of there, to Delphi, and no gas of value has been found along that line or north of it, because the strata north of the river *ascends toward* the fissures. South of the river gas has been found in abundance, because the strata *ascends from* the fissures up to the roof of the Wabash arch. Leaving the fissures at Delphi, the Wabash river cuts through the low rock barrier and flows southward to the Ohio. Northwestward from Delphi (near Francisville) where the Niagara rocks again assume the form of a wide flat bubble, gas is found in considerable quantity, showing that wherever the Trenton is lifted and the Niagara left arched but *unbroken*, gas may be looked for with confidence. I am not prepared to venture an explanation of the correlation between rock-arches and gas accumulations further than to suggest the simple law governing the escape from imprisonment of any substance lighter than air when an opening is presented to it. Wherever the strata confining gas are fissured down to the gas, the gas will escape. Along the way of the Wabash River the rocks are fissured and the gas north of the river has escaped because the Trenton reservoir is *lower* than the fissure; but south of the river the Trenton reservoir being *higher* than the fissure the gas is retained wherever its pressure has been resisted by columns of water, oil or other matter flowing into the fissure, and also into the lower planes of the reservoir; for it is evident that gas will expand until it finds the limit of resistance in every direction. Long before a bore was sunk at any point on the Wabash River I predicted, in accordance with this view, the finding of gas in the area northeast of Kentland, that is in the region of Francisville, and I also predicted the failure to find it at Kentland, Delphi and all along the Wabash, and north of it in a general way, from Delphi eastward, predictions which so far have not failed.

On the Blair farm, about two miles southwest of Francisville, five wells have been sunk, gas being found at a depth of 618 to 625 feet, the drill beginning in the Niagara rock, which is here overlaid with from 6 to 12 feet of modified drift and soil. At a depth of from 10 to 180 feet the drill encounters crevices, cavities and tilted rocks which greatly impede progress. Indeed, the Niagara strata all the way down are broken and uneven, the layers very much slanted and the texture gnarled and refractory.

At a number of points in the Francisville region the Niagara limestone crops out and is fissured and disturbed. On Prewett's farm, five miles northwest of Francisville, there is a sudden drop in the surface of the Niagara limestone. Two wells sunk there show the Niagara at the surface on one side of a narrow marsh, while at the other side a 30 foot stratum of the black Devonian shale is 60 feet under the drift and lying quite level. The two points are less than a furlong apart on a level prairie. This condition of the strata shows either a fault or a sudden dip of the Niagara limestone

In digging a well in the edge of Jasper County, four and a half miles northwest of Francisville, a vertical crevice was found in the Niagara limestone out of which rose a strong vein of water. The crevice was a foot in width and filled with "quick-sand," into which poles were thrust many feet without finding bottom. In this sand were found the bones and antlers of a deer.

On Pinkamunk River, seven miles west of Francisville, there is a sudden dip, or change in level, of one hundred and ten feet in the Niagara limestone within less than a quarter of a mile. The black Devonian shale is always found in the lower planes of these faults or "drops," or monodines, as the case may be, showing that it has been deposited nonconformably.

It may be well to remark just here that in this study I have taken no account of the stratum of water-lime rock, varying from nothing to thirty or more feet thick over most of the Niagara area north of the Wabash. I have treated it as "Niagara limestone," as it appears to have been affected by the disturbance here under consideration, and, moreover, it has been hard to distinguish it at most points.

The following table contains a partial list of sudden changes of elevation in the Niagara limestone near Francisville, Kentland, Monon, and Delphi:

Delphi	150	feet	in less	than half a	mile.
Francisville	110	"	"	"	quarter-mile.
Francisville	90	"	"	"	furlong.
Kentland	250	"	"	"	mile.
Monon	60	"	"	"	mile.

The above changes of level in a number of instances would be much greater if we calculated the truncated part of the eroded cones. All these inequalities might be referred to the effect of glacial action were it not for the Devonian deposits found resting in level strata above and around them, and for the uptilted, broken, warped and distorted condition of the Niagara rock strata.

The gas found on the Blair farm, above referred to, is of excellent quality, dry, clean and almost odorless, burning with a strong, clear flame. It is found in a grayish magnesian shale, or granular, laminated magnesian limestone, of open porous texture, lying in the dividing line between the Hudson River and the Niagara formations. The gas-bearing stratum is about twenty feet thick, and below it are the Hudson River and Utica shales overlying a very hard close-grained, cherty and barren Trenton limestone. This fertile dividing "seam" afforded a sharp flow of heavy oil in the first well at Francisville at about 630 feet below the surface.

Taking now a wide survey of the area north of the Wabash River, and west of a north and south line through Logansport, we shall find that the surface of the Devonian shale at Valparaiso is seventy-two feet lower than the surface of the Niagara limestone at Francisville, the same shale at Oxford is 367 feet lower than the Niagara at Francisville, and at Monticello the Niagara is 258 feet lower than at Francisville. This view shows that the sudden breaks near Francisville are not local merely, but part of a great Niagara disturbance which runs across the State. Moreover it clearly demonstrates, in connection with the other facts set forth in this paper, that the Devonian and other stratified formations superior to the Niagara, have not been affected by the disturbance, and that therefore they have been deposited since the disturbance took place.

The chief economic interest attaching at present to the Wabash Arch is connected with the gas and oil deposits found within the hollows of its porous folds. As far as the arch goes both gas and oil are likely to be found save in those areas where the rocks have been so broken as to permit the escape of these substances. In this connection it is interesting to note that in the broken and crushed Niagara rock at Monon the oil has evaporated until there is left in the crevices a tough bitumen of a very dark brown, almost black color, exceedingly heavy and coal-like. The gas has escaped through these crevices, leaving this residuary bitumen to tell the story of its departure. It is entirely possible, almost probable, that a considerable area of paying oil deposit may yet be found on the northern and northeastern slopes of the Wabash Arch. Indeed, some wells already sunk give great encouragement, notably those at Royal Center.

FOSSILS AND THEIR VALUE.

WILL H. THOMPSON.

I.

THE USE OF FOSSILS.

In writing for the understanding of the people generally, it is hard to find terms or phrases suited to convey clearly the nature and the importance of that connection which a knowledge of fossils bears to an intelligent study of even economic geology, Every geologist knows full well that most people verily believe science to be a humbug. There is an abiding popular faith in what is called "practical knowledge," a phrase that covers all manner of blunders, discouragements and disasters. Science is, in fact, the only true practical knowledge, and there is no such thing as permanent success disconnected from business done upon scientific principles. Geology, for instance, is simply a knowledge of the earth's materials. Out of these materials come all the substances which go into the arts, the commerce and the subsistence of mankind. Geology is not, therefore, a mere study of rocks for curiosity's sake. It is the study of the earth for man's sake. To properly study the earth we must first get possession of a key to its secrets, or to a part of its secrets, at least. It has been demonstrated that the fossils found in the rocks furnish this key. Geologists know this so well that they take it too much for granted that the people know it also. It would seem to be the duty of this department to write for the people rather than for the geologists. The people of Indiana pay for the geological work of the State in order that they may be nformed, along with all the rest of the world, upon the matters connected with a proper understanding of Indiana's physical resources. Many persons of considerable intelligence come to the museum of minerals and fossils, and go away scoffing at the possibility of such a collection of objects ever having any bearing whatever on the development of the State. So-called "practical" men are fond of asserting that all geologists are cranks, and all scientific investigators mere theorists. One thing, however, is very notable; there is not a single instance on record of a man who, after giving geology a fair study, ever denied that its importance is very great. It is those only who are ignorant of the truth who profess a contempt for it.

Coming now to a short study, in the plainest way, of the relations between a practical knowledge of fossils and the proper understanding of the formation of the earth, let us first take the simplest examples at our command. If any particular general deposit of stratified rock be examined we shall find certain fossil forms, either vegetable or animal, or both, peculiar to that rock alone. This being demonstrated, we may be certainly able thereafter to identify the rock by its fossil forms, no matter in what locality found. By long study and careful comparisons, geologists all over the world have been able to describe, figure and classify a vast number of these fossils and assign to each genus and species its locality or horizon in the rocks of the earth. Hence it is that a museum of fossils has a great value, as it holds the specimens from which it is easy to determine the name and locality, as well as the peculiar formation holding it, of any fossil in question. For simple instance, a citizen of Indiana living in Carroll County came to the State Geologist and claimed that he had found coal while boring a well in that county. The Geologist immediately told him that he was mistaken, that it was quite impossible for coal deposits to exist in the region indicated. How did the Geologist know this? He knew it because he had fossils from the topmost fossil-bearing surface rocks in that county, which showed those rocks to be of the Devonian age—rocks deposited long prior to the rocks of the carboniferous or coal-bearing age. This was a test which could not fail. The apparently useless fossils of the cabinet, and the apparently dry and useless reports of the State Geologist, here showed their value to the citizen, who, but for their information, would have been tempted to expend large sums of money in trying to demonstrate that Devonian black shale is coal. Another case in point was that of a gentleman who, in boring a well for gas, struck a very hard stone which he reported to be gray granite. The State Geologist asked for a piece of the stone, and a fragment was brought to him, which contained a fossil of the Niagara limestone, and which readily dissolved under the action of acid. Here was perfect proof that the rock reached was not granite, but was limestone and of the Niagara formation, a formation which lies far above the granite when in place. It is true that limestone is easily distinguished from granite by the naked eye, but the testimony of the fossils goes to the age of the rock and its proper place in the crust of the earth. It is testimony which always amounts to conclusive evidence. No man who knows whereof he speaks will ever contradict it, nor is there any better source of evidence likely to be discovered touching the remote history of the processes of nature.

So it will appear plain to even the most unscientific mind that fossils really have a use, and may serve civilization a valuable turn; for the moment that a cabinet of specimens ceases to be a mere collection of curiosities, it begins to take on a practical and precious significance to the student and to the broad-minded business man as well.

It is not, however, the greatest value of geology that it has a strong bearing upon the physical development of the countries in which its results are applied. There is a higher function of the science, which is to broaden the intelligence of the world, and thus to aid in impelling civilization along the best lines of progress.

What are fossils? In a general way, a fossil is any object, organic or inorganic, which has been preserved in the rocks of the earth, and which testifies of a past period of terrestrial life. Even the implements made by prehistoric men are, if found imbedded in the earth, strictly fossils. This admitted, the view widens at once, and we see that the study of these unearthed remains may tell a story even more reliable and indisputable in many particulars than the written histories left us by men.

That fossils are of great use, then, can not be questioned. They are the alphabet of that language in which the records of nature are written on the rock tablets of our earth. This alphabet must be learned before those records can be read and understood; and, after all, the lesson is not so difficult as it might at first appear to be. Much depends upon the spirit in which the task is undertaken.

II.

THE NATURE AND DISTRIBUTION OF FOSSILS.

Organic fossils are of two kinds, *animal* and *vegetable*, and they represent a great variety of genera and species, most of them quite extinct at present.

Inorganic fossils, as we shall consider them, are confined chiefly to objects manufactured by prehistoric men.

Animal remains, found in a fossil state, are distributed throughout the sedimentary rocks of the earth from the lowest limestones of the lower Silurian formation up to the most recent deposits on the surface of our alluvial areas. It is scarcely necessary to consider here the shadowy and doubtful remains claimed to have been found in certain of the older rocks. We may safely begin with the lower Silurian limestones as the lowest legible register of the fossil history of animal life. These fossils appear to have been almost wholly deep sea animals of simple structure comparatively and of a low order of life. A great number of them can be compared in general structure with the simpler shell-fish of the present time, and, so perfectly have their forms been preserved, we can figure, describe and classify them with almost as much accuracy as can be applied to living organisms. Moreover, the science of comparative anatomy has been so perfected that we can certainly assign to every part of any fossil form its function in life, and thus demonstrate the habits and mode of existence, and finally the habitat of the animal while living. Indeed it is perfectly possible for the expert comparative anatomist to reconstruct the form of an extinct species by the clue furnished through the study of a single and even minor part of the animal.

It has been shown by a comprehensive survey of all the best defined facts resulting from paleontological study that organic life has probably developed gradually from a lower to a higher state, and from general to special forms through all the past ages. The nature and the distribution of fossils settle this theory pretty clearly, and the facts of the post-fossil period do not conflict with it.

From the Lower Silurian to the Upper Silurian, thence to the Devonian and on up through the Carboniferous to the Drift deposits, the rocks of Indiana are marked by characteristic fossils by which each stratum may be distinguished from all the others. The same may be as well said of the stratified rocks in every country on the globe.

Vertebrate animals have left their remains in these rocks, so as to be certainly identified as far back as the Devonian age, early in which fishes must have swarmed in the waters. In the Devonian strata of Indiana, however, few perfect impressions of these fishes have been found, though teeth, scales and fragments of other parts have been gathered in great abundance, mostly in a rather imperfect state, owing to the conditions under which they were deposited.

The Carboniferous Age is represented by rocks bearing a wonderful amount and variety of plant fossils, the vast deposits of coals themselves being the result of vegetable accumulations. Besides the plants, these interesting rocks contain a great number of curious and characteristic sea animals, among which the crinoids have, perhaps, attracted most attention, though the *pentramites*, the *archimedes* and the *star fishes* have claimed a great deal of discussion.

The fossils of the Drift proper are water-worn and ice-worn pebbles and bowlders (these may properly be termed fossils in this connection) and worn fragments of coal, iron ore, granite and greenstone set in a body of peculiar blue clay. These inorganic fossils antedate and underlie the superficial formations in which are found the remains of the mound-builders, the flint, copper and pottery implements of various Indian tribes, and the skeletons and fragmentary remains of various huge extinct animal species like the mastodon and mammoth.

A large number of so-called sub-fossil remains have been unearthed from the alluvial deposits of Indiana, but these have no important bearing upon the geology of the State, the species being such as are still extant in the regions where the specimens were found. It is well, nevertheless, to examine them carefully.

III.

THE IMPORTANCE OF COLLECTING AND PRESERVING FOSSILS.

If intelligent people generally would take a reasonable interest in collecting and preserving fossils, most excellent results would be sure to follow, especially if the fossils were promptly donated to the State museum. Indeed it is very strange that so little is done in this way for the upbuilding of a great collection dedicated to the use of the people. The State Geologist can accomplish but a small part of what could be effected if he had the hearty help of active and intelligent men and women all over the State, who would send him the results of their work done in leisure moments. While it is true that a large number of the fossils taken by any collector will be practically without any value, it is also true that now and again something new, instructive and sometimes very valuable will turn up. It is a common and very foolish mistake to imagine, however, that money can be made by collecting fossils for sale. The sooner this notion is cast aside the better for everybody. The only worthy reward to which the collector can look forward is the satisfaction of knowing that he has done something to aid in the general advance of scientific investigation, and that he has thereby added something to a study which will widen the scope and enlarge the powers of our civilization. The collecting of a great museum of organic remains for our State should be a matter of interest and pride to every good citizen, and it is to be hoped that in the future more will be done to help in the matter than has yet been thought worth while. A great many small private collections exist all over the State; these are quite worthless, save as curiosities, to their owners, while if they were donated to the State and properly set up in the museum they would become for all time the source of education and profit to all the people of the great commonwealth. This is especially true of the relics of prehistoric men—the flint, copper, bone and pottery implements and ornaments found here and there all over the State. Such collections, while they are cumbersome, inartistic and quite out of taste and place in a private house, are the fitting furniture of a great popular museum. Their only value is in connection with a public exhibition which should be as permanent as the government itself, and to this all private collections should be promptly and willingly donated.

IV.

HOW TO COLLECT FOSSILS.

The chief thing in the makeup of a successful collector is a pair of good eyes, the next thing is a habit of close and accurate observation, then comes a knowledge of the great value which may attach to the very simplest objects in nature, and finally perseverance.

Singularly enough, a prejudice exists in the minds of people against the collector; by them he is looked upon as a harmless but misguided "crank" wasting his life on a pursuit too utterly unprofitable to be worth the notice of intelligent and energetic manhood. This is chiefly because the objects and the remote results of science are not palpable, present things, subject to the immediate test of popular experiments. On account of this well-known prejudice many persons who otherwise would devote much time to observing and collecting can not muster up courage to face the current of vulgar comment. The writer of this paper only a few days ago was accosted by a man who saluted him thus: "Hello! nosin' round 'mongst the dornicks, eh! Findin' many periwinkles these days? How much are ye a givin' for snail-shells an' injin flints now?" Here was a different phase of the same spirit which formerly made martyrs of all investigators. The collector and student of nature must expect that he will meet this spirit, and unless he be able to meet it cheerfully and as a matter of course, he will be sure to accomplish very little. On the other hand, however, he will find many friends and helpers; men and women who, unable or unprepared to give attention to science, are still willing and anxious to offer every aid in their power to make the way easy for those who are devoting their lives to the work of collecting the facts upon which knowledge is based.

The tools of the collector are few and very simple. A good steel hammer with a rather long poll at one end and an edge at the other is the most important; it should have a strong but slightly elastic helve about twelve inches long, and may be carried in one's pocket. This is to be used in breaking the stones and in extracting fossils where it may be done without very careful work. A small cold chisel of very hard and tough steel is very useful in taking out delicate fossils where it is necessary to cut round them with great care and caution. Armed with these two simple implements a fairly expert person can be very successful in obtaining specimens of all the organic forms discoverable in outcropping rocks. Of course, when excavation becomes necessary the usual quarrymen's tools must be used. A basket for carrying collected specimens is very handy.

One thing most often overlooked by even expert collectors is to keep a perfect record of the place and the rock in which each specimen is found. This should never be neglected for a moment. Always carry a book and a pencil for the purpose, and so soon as a specimen is taken, make a careful descriptive note of the fact together with an account of the surroundings; then mark each fossil to correspond with the entry in your book; by this means all mistakes may be avoided. Without such a record a collection may be almost useless.

When a collection is being made for private purposes the collector can confer a great favor upon the State, and at the same time add value to his own fossils by sending duplicates to the State Geologist, who will take great pleasure in assisting in their identification, both for the collector and the State Museum. Private collections donated to the State will be labeled with the donor's name and thus become a permanent monument to his public-spirited and liberal act. Of course it is quite impossible for one not an expert to know much about the interest or the scientific value of what he may collect, but he will always find men of science ready and anxious to give him every aid in their power. If intelligent people generally could be induced to take a fair interest in building up a great State Museum we should soon succeed in the work. A magnificent foundation is already laid, and no room in the State Capitol is more visited or better enjoyed by the people of the State. It is to be hoped that greater interest than has been heretofore manifested may be taken in this subject.

V.

FOSSIL BEDS OF INDIANA.

No State in the Union has greater or more varied fossil beds than has Indiana. From the Ohio River to as far north as the stratified rocks are found outcropping most interesting deposits, rich in remains of both animal and vegetable organisms, have been worked with great success by collectors and learned explorers. Ever since the days of Owen and Lyell the rocks of Indiana have demanded and received the attention of the best paleontological experts, but not until within the last twenty years have the strata generally been cut in every direction by railroads to an extent that has rendered their contents easily approachable by the collector. Along with the advance of great internal improvements in the State, science and scientific methods of investigation have been making rapid progress. The common school system, the enterprise and learning of our newspaper and magazine publications, the liberal and enlightened policies of our pulpits and our colleges, and more than all, perhaps, the restless, inquiring, investigating spirit of our people have pushed forward the study of every material interest, and this has forced the study of geology and its kindred sciences upon us as a matter of practical importance. Consequently, all the best known and richest fossil beds as yet discovered in Indiana have been pretty thoroughly explored and studied by very competent men. The coal-measure fossils of Indiana, especially the vegetable forms, have had the least attention, while those of the Lower Silurian, the Niagara group and the Keokuk shales have become most widely known. Certain coral forms of the Devonian formation, however, have been most thoroughly studied and figured. The black shale of the Devonian has not had due attention, its fossils being of very rare occurrence, and so few of them have been found that there is yet room for doubt as to the rock's geological identity. To this shale the enthusiastic student may turn for investigation, with a chance to win his spurs in science by collecting a suite of fossils, from which the deposit can be certainly placed. It is not to the famous fossil mines that one must go for something new, but to those as yet undiscovered. Still, for the information of persons interested in collecting for museums and colleges, it may be well to call attention to a few of the richest deposits in the State, with some descriptive notes of a general character.

SPERGEN HILL.

This famous deposit of sub-carboniferous fossil forms is in Washington County. The rock in the "hill" is cut up by the L., N. A. & C. Railroad, and is exposed in heavy masses of easily disintegrated limestone, which weathers to dark reddish clay, leaving well preserved fossils comparatively free from adhering matter. This railroad cut, known as the "Spergen Hill cut," is east of Salem about five miles, and within fifteen minutes walk of Harristown. The rock is the lower bed of the St. Louis group, and is usually called the "Warsaw Bed." Beginning on page 138 of the Fifteenth Report of this Department, the reader will find a list of the fossils taken from this bed; it was carfully prepared by Prof. S. S. Gorby, who made an able report of the geology of Washington County. In the Twelfth Report of this Department, made by Prof. John Collett, may be seen excellent figures and descriptions of a great many Spergen Hill fossils, from which sufficient information may be had to enable any intelligent person to identify nearly all the more common forms. It might as well be admitted, however, that the Spergen Hill beds seem to have been practically exhausted; but, doubtless, there are other places where the same fossils are quite as plentiful, and where new forms might be found associated with them. At least it is well worth while to look for new beds.

THE WALDRON FOSSIL BED.

All over the enlightened world the shales of Waldron are familiar to students of paleontology. This deposit outcrops along Conn's Creek, in Shelby County, and in many places over a small area, including a part of Rush County. It is a laminated, friable so-called "soapstone," consisting of clayey shales and partings supposed to clearly mark the dividing line between the Upper Silurian and Devonian formations. Nowhere in the world has there been found a more interesting and productive bed of rarely preserved fossils of the upper Niagara rocks than that of Conn's Creek. The rock is of a blue or grayish blue tinge, rapidly weathering to a rusty yellow, and crumbling when exposed to the atmosphere. In places it is a mass of fossils whose forms have been retained with remarkable nicety after showing the minutest details of structure. Some of them are of grand size, notably species of *gyroceras* and *orthoceras*, whilst others show forms of exceeding delicacy and beauty.

Professor Hall, of New York, has described a large number of these, many of which will be found figured and described in the Eleventh Report of this department, then directed by Prof. John Collett, State Geologist, whose work has been of great value to science and to the people. Not a few of the so-called Waldron fossils remain yet unfigured and undescribed, offering to the ambitious student a beautiful field for original work.

THE LOWER SILURIAN BEDS.

These are so common in the area of Hudson River outcrop that no description is necessary. A great many fine specimens are taken in the vicinity of Richmond, and thence southward fossil deposits are numerous to the Ohio River banks.

DEVONIAN BEDS.

Near the falls of the Ohio River, at Jeffersonville and New Albany, the coral forms of the Devonian rocks are found in most perfect preservation. Prof. Davis, of Louisville, and Mr. George K. Green, of New Albany, have done a great deal to bring before the world these magnificent fossils. Specimens of grand size and so preserved as to show every line of the beautiful and delicate coral structures have been sent to all the principal museums of the world. Prof. Davis has photographed, figured and described these in a great work soon to appear and for which the world of science will be under lasting obligations to him. As a preliminary study to this work the student would do well to visit the great Devonian coral beds.

COAL-MEASURE FOSSILS.

The fauna and flora of the coal-measure rocks have not had due study in Indiana. Prof. Collett, it is true, did all in his power, and Prof. Cox made every exertion during the necessarily cramped and rapid survey of the coal fields, but the money and time at command could not permit them, or either of them, to make that minute and leisurely examination which alone can afford valuable results in paleontology. The work of the present State Geologist has been entirely outside of the coal-measures area and consequently nothing in this field could be done by him. For plant species the collector in the coal-measure rocks may look in the shales above and in the fire-clays below the seams of coal, with most confidence, but often beautiful remains are found in the sandstones and limestones between the seams, especially where they are of a shaly nature. The animal remains are mostly found in the harder rocks and often in clay and iron nodules or concretions which when split open disclose the fossil. Some very beautiful plant impressions are also found in these concretions. In Vermillion, Fountain, Clay, Vigo, Daviess and Sullivan counties, and from there southward to the Ohio River, are outcroppings of the coal-measure rocks from which characteristic fossils may be taken, and this is the most interesting and promising field left to the energetic collector. In this field a few insect remains may be found, as indicated by a few specimens from Orange County. In Tippecanoe County some sub-carboniferous fossils (very interesting as throwing light probably upon the earlier forms of a few coal-measure fossils) have been taken by Professor Gorby, but they are not yet figured.

WATER LIME (LOWER HELDERBERG) BEDS.

The survey of the State is just now at the point of examining and studying this important group of rocks, and as yet the fossils therein have not been sufficiently compared and classified to admit of detailed report. Professor Gorby and the writer of this, together with the State Geologist, have traced these rocks almost across the State from east to west, and have found the deposit of varying thickness and composition, but always bearing the general characteristics of the water lime wherever found. Usually it occurs in thin layers of bluish colored impure limestone, but at times it tends to become grayish and more compact. In the gas wells of the northern part of the State the drill passes through this formation, and, owing to the thickness there of the Niagara limestone, some geologists have made the mistake of supposing that the water lime is of unusual depth, when in fact it is not. The Niagara rocks of middle and northern Indiana have been greatly disturbed and lifted, and this has given rise to many untenable theories, among which that of the great thickening of the water lime rock is the chief. Professor Gorby, who certainly has had the best opportunity to study the formation, will soon make a most interesting and authoritative report touching the water lime group in Indiana. Meantime, the attention of geologists and collectors is called to this field with the hope that all the information possible may be gathered by this department on a subject which is very important from both the scientific and the economic point of view. As the drillings from gas wells are very unreliable and rarely contain perfect fossils, careful studies of all the outcrops of water lime will be of prime interest. The State Geologist will deem it an especial kindness if any collector will send to the office fossils found in this formation in Indiana, accompanying each with a definite description of the place and the rock wherein it was found.

KEOKUK CRINOID BEDS.

Perhaps the most famous crinoid beds in the world are those in the bank of Rock River (or Sugar Creek), near Crawfordsville, in Montgomery county. In the report of this Department for 1875, Prof. John Collett, then Assistant to the State Geologist, made a list of the fossils found in that bed so far as they had been figured and described at that time, but since then considerable additions have been made. As the crinoids are the most interesting, a corrected list of them is appended to this paper; it is furnished by Mr. Charles Beechler, to whom I am greatly indebted.

The history of the Crawfordsville crinoid bed is curious, and tends to show how slow have been the movements of science in the West.

The first specimen, an *Actinocrinus*, was found by Prof. E. O. Hovey, of Wabash College, in 1842. One of the finest specimens ever found was an *Onychocrinus exculptus*, which appeared in the Scientific American of July 12, 1887. Between 1842 and 1875, a period of thirty-three years, the beds were worked now and again by different persons. O. W. Corey, of Crawfordsville, a man without training in science, did a great deal toward developing the wealth of the deposit. Prof. Bradley, who was working at one time for Prof. Hovey, of Wabash College, made known to Prof. Marsh, of Yale College, the extent and importance of the beds, and was employed to make a collection for the latter institution, which he did. A fine collection of specimens was sent to the British Museum by Mr. Charles Dyer, of Cincinnati. Professor Hovey made large collections, but there was no detailed local study made which could be called authoritative; the specimens were sent to this, that and the other supposed authority to be passed upon, and very soon no little confusion prevailed in classfication and nomenclature.

From 1858 (in which year two specimens were named—one by Hall and one by Lyon and Cassidy) to 1881, thirty-two species now known to have been found in these beds had been named. Through the steady industry of Professor Hovey, Wabash College slowly drew into her museum a very fine cabinet of crinoid forms, some of which are extremely rare, but a far greater number of the choicest fossils found their way to distant States and to alien countries. Few of the educational institutions of Indiana have secured even a fair collection of these beautiful and instructive remains.

The beds appear low in the bluffs of Sugar Creek (Rock River) underlying a heavy and impure sandstone. The fossils are imbedded in a bluish gray shale which is variably silicious, soft when first exposed, but soon hardening into a refractory state, which renders the specimens difficult to clean if not attended to at once.

Recently Mr. Charles Beechler, to whom I am so much indebted, has been working the beds successfully for Professors Wachsmuth and Springer, whose studies of crinoids are, perhaps, the most thorough in existence, and whose collections are among the best and most extensive to be found anywhere.

*CORRECTED LIST OF FOSSILS FOUND AT CRAWFORDSVILLE, IND.

BY CHARLES BEECHLER.

PORIFERATA.

1884. *Cleodictya gloriosa*, Hall, 35th An. Rep. N. Y. Mus., page 479.

1884. *Cleodictya? mohri*, 35th An. Report N. Y. Museum, page 479.

1881. *Dictyophyton cylindricum*, Whitfield, 35th An. Rep. N. Y. Mu., page 475.

1882. *Ectenodictya (Phragmodictya) eccentria*, Hall, 35th An. Rep. N. Y. Mu., page 476, pl. 20, fig. 1.
Lyrodictya romingeri, Hall, 35th An. Rep. N. Y. Mu. page 476.

1881. *Phragmodictya (Dictyophyton) catillaforme*, Hall, 35th An. Rep. N. Y. Mu., page 477, pl. 21, figs. 1—6.

1882. *Phragmodictya lineata*, Hall; 35th An. Rep. N. Y. Mu., page 478, pl. 21, fig. 8.

1884. *Phragmodictya patilliformis*, Hall; 35th An. Rep. N. Y. Mu., page 478.

1884. *Physospongia alteranta*, Hall; 35th An. Rep. N. Y. Mu., page 481, pl. 20, figure 9.

1884. *Physospongia colletti*, Hall; 35th An. Rep. N. Y. Mu., page 480, pl. 20, figure 7.

1882. *Physospongia dawsoni*, (Whitfield) Hall; 35th An. Rep. N. Y. Mu., page 479, pl. 20, figs. 4, 6, 8.

CŒLENTERATA.

[Several specimens of the genus *Zaphrentis* have been found at this locality, but no definite species have yet been determined except in one case; Ind. Geol. Rep. 1875, gives *Zaphrentis dalli* Edwards and Haime, also the species *Aúlopora gigas*, Rominger, *Amplexus fragilis*, White and St. John, *Syringopora* (sp.?)]

*Part of this list was published in the American Geologist, December, 1888.

ECHINODERMATA.

CRINOIDEÆ.

Species marked with an * are referred to said genus for the first time by Charles Wachsmuth and Frank Springer in their work on the revision of the Palæocrinoidea from which this list of crinoids has been compiled.

1881. *Agaricocrinus springeri*, White. Geol. Rep. Ind., 1881.

*1868. *Barycrinus herculeus*, Meek and Worthen. (*B. hoveyi* var. *herculeus*) Proc. Acad. Nat. Sci., Phila., p. 341. Geol. Rep., Ill., vol. v, p. 485, pl. 13, fig. 2.

1861. *Barycrinus hoveyi*, Hall. (*Cyathocrinus hoveyi*) Desc. New Pal. Crin. p. 5, Bost. Jour. Nat. Hist., p. 293. Meek and Worthen, 1873, *B. hoveyi*, Geol. Rep. Ill., vol. v. p. 486, pl. 13, fig. 1.

*1859. *Batocrinus indianœnsis*, Lyon and Casseday. (*Actinocrinus indianœnsis*) Amer. Jour. Sci. and Arts, vol. xxix, p. 75. Meek and Worthen, 1873. *Actinocrinus indianœnsis*, Geol. Rep. Ill., vol. v, p. 341.

*1880. *Batocrinus wachsmuthi*, White. (*Actinocrinus wachsmuthi* not *A. wachsmuthi* 1862—*Actinocrinus scitulus.*) Author's Edit. from 12th Annual Rep. U. S. Geol. Surv. by Hayden, p. 162, pl. 40, figs. 1 a. b. Geol. Rep. Ind., 1879–80, p. 142, pl. 7, fig. 6.

1869. *Calceocrinus bradleyi*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 73, also 1873 Geol. Rep. Ill., vol. v, p. 502, pl. 14, fig. 9.

1868. *Catillocrinus bradleyi*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 342; also 1868, Geol. Rep. Ill., vol. v, p. 504, pl. 14, figs. 10 a. b.

1865. *Cyathocrinus arboreus*, Meek and Worthen. Proc. Acad. Nat. Sci., Phil., p. 160; also Geol. Rep. Ill., vol. iii, p. 520.

1879. (?) *Cyathocrinus harrisi*, S. A. Miller. Jour. Cin. Soc. Nat. Hist., vol. ii, pl. 15, fig. 2.

1869. *Cyathocrinus inspiratus* (?), Lyon, Trans. Amer. Philos. Soc., vol. xiii, p. 457, pl. 27, fig. k.

1859. *Cyathocrinus multibrachiatus*, Lyon and Casseday. Amer. Jour. Sci. vol. xxviii.

1870. *Cyathocrinus poterium*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 24. Geol. Rep. Ill., vol. v, p. 489, pl. 12, fig. 4.

1860. *Dichocrinus ficus*, Casseday and Lyon. Proc. Amer. Acad. Arts and Sci., vol. v, p. 24; Meek and Worthen, 1873; Geol. Rep. Ill., vol. v, p. 500, pl. 14, fig. 1.

1860. *Dichocrinus polydactylus*, Casseday and Lyon. Proc. Amer. Acad. Arts and Sci., vol. v, p. 20.
Syn. *D. expansus*, Meek and Worthen (not De Kon. and Leh., 1853.) Proc. Acad. Nat. Sci., Phila., p. 344; also Geol. Rep. Ill., vol. v, p. 500, pl. 14, fig. 1.

1858. *Forbesiocrinus Wortheni*, Hall. Geol. Rep. Iowa, vol. i, pt. 2, p. 632, pl. 17, fig. 5.

*1859. *Ollacrinus tuberosus*, Lyon and Casseday. (*Goniasteroidocrinus tuberosus* and type of that genus.) Amer. Jour. Sci. and Arts, vol. xxviii, (ser. 2) p. 233; Wachsmuth and Springer, Proc. Acad. Nat. Sci., Phila., p. 263.

1859. *Onychocrinus exsculptus*, Lyon and Casseday. (Typical species.) Amer. Jour. Sci., vol. xxix, p, 78.
Syn. *Onychocrinus* (*Forbesiocrinus*) *norwoodi*, Meek and Worthen. Geol. Rep. Ill., vol. ii, p. 245, pl. 18, fig. 3.

*1859. *Onychocrinus ramulosus*, Lyon and Casseday. (*Forbesiocrinus ramulosus*, L. and C. not Hall.) Amer. Jour. Sci., vol. xxviii, p. 235.

1865. *Platycrinus hemisphericus*, Meek and Worthen. (*Pleurocrinus.*) Proc. Acad. Nat. Sci., Phila., p. 162; also Geol. Rep. Ill., vol. iii, p. 466, pl. 16, fig. 9, and vol. v, p. 16, fig. 6 a. b. c.

1870. *Poteriocrinus* (*Pachylocrinus*) *concinnus*, Meek and Worthen. (*Pot.* [*Zeacrinus*] *concinnus.*) Proc. Acad. Nat. Sci., Phila., p. 26; Geol. Rep. Ill., vol. v, p. 490, pl. 14, fig. 3.

1869. *Poteriocrinus* (*Scaphiocrinus*) *coreyi*, Meek and Worthen (not *Pot. coreyi* Worthen. Geol. Rep. Ill., vol. vi, p. 514.—*Pot. Scytalocrinus grandis*, W. and Sp.) Proc. Acad. Nat. Sci., Phila., p. 148; Geol. Rep. Ill., vol. v, pl. 15, fig. 1.

*1870. *Poteriocrinus* (*Decadocrinus*) *depressus*, Meek and Worthen. (*Scaphiocrinus depressus.*) Proc. Acad. Nat. Sci., Phila., p. 27; Geol. Rep. Ill., vol. v, pl. 14, fig. 8.

1878. *Poteriocrinus* (*Scaphiocrinus*) *gibsoni*, White. Proc. Acad. Nat. Sci., Phila., p. 31.

*1879. *Poteriocrinus* (*Scytalocrinus*) *grandis*, Wachsmuth and Springer. (Described *Poteriocrinus coreyi*, Worthen 1875.) Geol. Rep. Ill., vol. vi, p. 516, pl. 29, fig. 2, 3, (not *Pot.* [*Scaphiocrinus*] *coreyi*, M. W. 1869.)

1878. *Poteriocrinus* (*Scaphiocrinus*) *gurleyi*, White. Proc. Acad. Nat. Sci., Phila., Pa. 32.

1865. *Poteriocrinus* (*Scytalocrinus*) *indianœnsis*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 155; Geol. Rep. Ill. vol. iii, p. 515, pl. 20, fig. 4.

1861. *Poteriocrinus nodobrachiatus*, Hall. Desc. New Pal. Crin., p. 8; Bost. Jour. Nat. Hist., p. 614.

1861. *Poteriocrinus (Scytalocrinus) robustus*, Hall. Desc. New Pal. Crin., p. 7; Bost. Jour. Nat. Hist., p. 315.

*1879. *Poteriocrinus (Pachylocrinus) subæqualis*, Wachsmuth and Springer. (Type of the group described by Hall, 1861, as *Scaphiocrinus æqualis*, not *Pot. Scaphiocrinus æqualis*. Hall, 1859.) Desc. New Pal. Crin., p. 8. Bost. Jour. Nat. Hist., p. 316. Meek and Worthen, 1873, Geol. Rep. Ill., vol. 5, pl. 15, fig. 6

1861. *Poteriocrinus (Scaphiocrinus) unicus*, Hall. Desc. New Pal. Crin, p. 8; Bost. Jour. Nat. Hist., p. 313; Geol. Rep. Ill., vol. v, pl. 15, fig. 5.

*1858. *Taxocrinus multibrachiatus*, Lyon and Casseday. (*Forbesiocrinus multibrachiatus*.) Amer. Jour. Sci., vol. xxiii. Labeled in most American collections, *Forbesiocrinus meeki*, Hall.

*1861. *Vasocrinus lyoni*, Hall. (*Cyathocrinus lyoni*, type of the genus.) Desc. New Pal. Crin., p. 5; Bost. Jour. Nat. Hist., p. 298, 1868, Meek and Worthen (*Barycrinus lyoni*); Proc. Amer. Acad. Nat. Sci., Phila., p. 340.

Syn. *Cyathocrinus hexadactylus*, Lyon and Casseday, 1859. Amer. Jour. Sci., p. 74.

BLASTOIDEÆ.

1858. *Penetremites wortheni*, Hall. Geol. Surv. Iowa, p. 606; also Geol. Rep. Ill., vol. v, p. 606, pl. 15, fig. 1.

ECHINOIDEÆ.

PERISCHOECHINIDÆ.

1868. *Lepidesthes coreyi*, Meek and Worthen. Geol. Rep. Ill, vol. iii, p. 525.

1878. *Lepidesthes colletti*, White. Proc. Acad. Nat. Sci., Phila., p. 33, 1880. An. Rep. U. S. Geol. Surv. Ter. for 1878, pt. 1, p. 163, pl. 40, fig. 2; 1881, Ind. Geol. Rep., p. 362, pl. 41, fig. 2, 2.

ASTEROIDÆ.

1868. *Onychaster flexilis*, Meek and Worthen. Geol. Rep. Ill., vol. iii, p. 526; also vol. v, p. 510, pl. 16, fig. 3.

1869. *Protaster gregarius*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 169; Geol. Rep. Ill., vol. v, p. 509, pl. 16, fig. 5.

EDRIOASTERIDÆ.

1868. *Agelacrinites (Lepidodiscus) squamosus*, Meek and Worthen. Proc. Acad. Nat. Sci, Phila., p. 357; Geol. Rep. Ill., vol. v, 513, pl. 16, fig. 1.

MOLLUSCA.

MOLLUSCOIDEA.

BRYOZOA.

1857. *Archimedes owenana*, Hall. Proc. Amer. Asso. Adv. Sci., vol. x.
1858. *Archimedes reversa*, Hall. Geol. Rep., Iowa.

BRACHIOPODA.

1861. *Productus magnus*, Meek and Worthen. Proc. Acad. Nat. Sci., Phil., p. 142; also Geol Rep. Ill., vol. iii, p. 528, pl. 20, fig. 7 a. b. c.
1809. *Productus punctatus*, Martin. Petrif. Derb.
(?) *Productus-semi-recticulatus*, Martin. Ind. Geol. Rep., 1880, p. 125, fig. 123.
(?) *Productus cora*, d'Orbigny. Voyage dans l'Amerique dele Meridionale. Ind. Geol. Rep., 1883, p. 125, pl. 26, fig. 1, 2, 3.
1870. *Spirifer fastigatus*, Meek and Worthen. Proc. Acad. Nat. Sci., Phil., p. 36; also Ill. Geol. Rep., vol. vi, p. 521, pl. 30, fig. 3.
1858. *Spirifer keokuk*, Hall. Geol. Rep., Iowa, vol. x.
1809. *Terebratula sacculus*, Martin. Petrif. Derb.

LAMELLIBRANCHIATA.

1866. *Aviculopecten indianœnsis*, Meek and Worthen. Proc. Chi. Acad. Sci., vol. i, p. 14; also Ill. Geol. Rep., vol. iii, p. 532, pl. 19, fig. 6, a. b.
1865. *Lithophaga? lingualis*, Meek and Worthen. Proc. Acad. Nat Sci., Phil., p. 245; Ill. Geol. Rep., p. 536, pl. 19, fig. 1, 2.

GASTEROPODA.

1860. *Platyceras equilatera*, Hall. Supplementary sheet to vol. i, pt. 2, Iowa Rep , p. 1; also Ill. Geol. Rep. vol. v, p. 518; also Ind. Geol. Rep., 1880, p. 514, pl. 17, fig. 2.

PTEROPODA.

1865. *Conularia sub-carbonaria*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 253; also Ill. Geol. Rep., vol. v, p. 520, pl. 19, fig. 4.
1859–60. *Conularia crawfordsvillensis*, R. Owen. Ind. Geol. Rep., 1859–60, p. 364, fig. 9.

ARTICULATA.

1870. *Phillipsia* (*Griffithides*) *bufo*, Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 52; also Ill. Geol. Rep., vol. vi, p. 528; also Ind. Geol. Rep., 1880, p. 515, pl. 4, fig. 5.

(The above is Mr. Beechler's list, and it is probably the nearest correct of any in existence.)

The writer of this paper has knowledge of another fine crinoid bed near Crawfordsville, but the owner and discoverer is not willing that its location shall be made public.

THE CHESTER GROUP PLANT BEDS.

In the coarser sandstones of the Chester group of rocks in Indiana are found many interesting vegetable remains, which have not yet been thoroughly studied. The eastern tier of the southwestern counties of the State offer here and there an outcropping of these rocks. These were examined by Professor Cox and Prof. John Collett, but owing to the hurried nature of the survey made, little was done in the way of collecting a complete suit of Chester plant fossils for the museum. The attention of students and the friends of science in that part of the State should be directed to this need of the Department, and it is hoped that the museum will soon receive specimens from this group of rocks. If the discovery of available beds of fossils were reported to the State Geologist it would greatly facilitate the work of filling up the cabinet, even if collectors should still continue to withhold their aid with the hope of making a paltry gain in money by selling their collections to parties outside of the State.

PLANT REMAINS OF THE DRIFT.

The Department museum is in possession of a limited cabinet of plant remains found in the drift deposits of the State. These are chiefly bits of wood taken from wells and other deep excavations. Vegetable mould, the decayed remains of leaves and twigs are quite often met with by well diggers below heavy deposits of bowlder clay. Such things are interesting and valuable for comparative study, and the Department is always glad to receive them. One of the obscurest and at the same time one of the most important questions connected with the past history of the earth may yet have great light thrown upon it by a minutely painstaking investigation of all the discoverable facts connected with the body of our drift deposits, and none of these facts is more burdened with valuable suggestions than the presence of vegetable remains intercallated between the solid beds of bowlder till. If each person who chances to observe such remains will but take the small pains to record all the surrounding conditions and to write a succinct description of the place where the discovery is situated, with all the attending features, we shall soon be in possession of most convincing evidence of the real truth concerning this great drift mystery, in one regard at least. Plant life is a sort of index to climate and to physical conditions on the earth's surface at any given time and place. If we can discover what manner of vegetation flourished at the coming on of a glacial era in the history of Indiana, we can describe with tolerable accuracy the climate and the soil in which such plants grew and thrived. If forms of vegetation known to be confined to tropical regions were found buried in our drift masses we should know at once that these forms had been grown in a climate far different from that now prevailing here. On the same principle boreal plant forms would tell of a frigid temperature prevailing in what is now a temperate area. Of course these suggestions are trite to the man of science, but to the average citizen for whom this report is mainly written, it is necessary that they should be presented in order that he may have a general idea of the value attaching to what may at first sight appear very simple and even very foolish investigations. It was well said that "knowledge is power," and often enough the knowledge which is greatest power comes out of circumstances as slight as the steam lifting the lid of a tea-kettle, or the falling of an apple from a bough.

The best points at which to search for drift plant fossils are to be found in deep railroad cuts, in the blue-clay bluffs of streams, and in the excavations of cisterns, cellars and wells. Any ancient bits of wood or other vegetable matter found in such places should be carefully preserved and have the examination of an expert. The State Geologist will always be glad to have them.

FOSSIL BONES, ETC.

A great many very interesting animal remains have been found in the post-glacial deposits of Indiana. These have been chiefly the fragmentary skeletons of animals now extinct, and mostly species of giant size, like the ancient elephants, sloths, tapirs and beavers. The habits and lives of these great and forever extinct beings are not yet understood, nor are the circumstances which brought about their extermination at all clear to even the most advanced students of nature. In the fourteenth report of this department Professor John Collett, State Geologist, presented a paper by Professor E. D. Cope and J. L. Wortman, in which the student will find a comprehensive guide to a beginning of this study, and a far more compact and condensed presentation of the same subject appears in the fifteenth report by the present State Geologist, Maurice Thompson. The figures in the fourteenth report and the description in both the fourteenth and fifteenth reports, will enable the ordinary collector to satisfy himself with reasonable certainty as to the probable value of any remains he may find.

Partial skeletons of the mammoth and the mastodon are the most common discoveries in our post-pliocene deposits, and, as I have already remarked, there is much yet to be learned from a close and detailed study of them. The fact that these remains are rarely found elsewhere than in marshy places where the animals appear to have perished in the mire of sloughs or bogs, has given rise to much speculation, but as yet no theory entirely satisfactory has been adduced. Vast numbers of teeth, jawbones and other more or less fragmentary parts of these colossal skeletons have been discovered by ditchers, and have been cast aside to fall to pieces under the action of the atmosphere. The State Museum has a very inadequate collection of such remains, and it is hoped that with a growing knowledge of science and an increased interest in the building up of a great center of study, the people will aid the department in procuring a large cabinet of specimens. Little, indeed, can be done without such aid freely and generously given.

RECENT AND CONTEMPORARY FOSSILS.

The museum of this Department has a large and most valuable collection of land and fresh water shells, most of which belong to existing species. These are scarcely to be classed with fossils proper, or even with what have been named sub-fossil forms; but many specimens of both land and fresh water species are to be found, well preserved, in the recent river and stream terraces, and in the cracks and crannies of our outcropping rocks, as well as in the loams and moulds of our woods and fields. The collecting of these forms has been followed very successfully by quite a number of enthusiastic persons in Indiana, but much still remains to be done. The older fresh water shells, such as are found in the loess or lacustral deposits, are of great interest, and specimens will be gladly received by the State Geologist. The southern and southwestern counties of Indiana have many of their hilltops capped with lacustral sediment, in which many new forms, doubtless, may be found. To this special field not enough attention has been given. A careful examination of all our loess and ancient river deposits might result in a considerable advance of our knowledge of the later forms of extinct fresh water animals. Moreover the materials of these deposits have not yet been studied sufficiently to make us acquainted with their elements of economic value, a matter well worth consideration.

MICROSCOPIC FOSSILS.

Swarms of infinitessimal animals and plants have passed into a fossil state and are found in the rocks. Many of these minute organisms are barely perceptible to the naked eye, while a still greater number can be seen only by the use of the microscope. The chalk formations of Great Britain are composed of fossil organic forms, named *Foraminifera*, which are not observable with the naked eye, but which have been carefully studied. So our oolitic limestones of Indiana show under the glass a solid mass of minute shells, which as yet have not been thoroughly examined and described. Indeed it may be said that the infinitessimal fossils of Indiana are practically unstudied, though some intelligent and very commendable work has been done in that direction. The use of the microscope affords a most pleasing and instructive method of studying nature and there is nothing difficult about handling the instrument, in fact for all ordinary purposes a very simple magnifying glass is quite sufficient, and it should be carried with the outfit of every collector and student. No form of life discoverable at all is too small or too simple for study. Every organism is significant as a link in the great chain of animate existence, reaching back into the dark and mysterious past. We can not afford to leave a single one unnoted if we would make the most of our possibilities in the way of tracing the records of that slow development which has brought life up to its present highly specialized and complicated forms.

Nearly all of our sedimentary rocks will be found bearing a number of these minute forms of animal remains more or less perfect and subject to very interesting comparative study with the glass.

Scarcely less attractive to the zealous student are the microscopic vegetable organisms whose traces have been left in the rock formations. The spores of ancient plants and the shells of *diatomacœ* come out clearly under a powerful microscope, and their study will be found of absorbing interest in connection with the higher botanical problems with which our advanced thinkers are at present busying themselves. Especially is it desirable to have the attention of investigating minds directed to a careful microscopic examination of the coal-shales, the fire-clays (and the coal itself) of all our coal-seams with a view to a settlement, if possible, of the question of their origin. It has been claimed by geologists of high authority that vegetable tissue and the spores of various plants have been found in the body of bituminous coal. If this can be well settled as true, it will go a long way toward proving the vegetable origin of our coal deposits. At the dividing line between the roof shales and the coal proper would seem to be the point where investigation might be best rewarded with discoveries of significance. The impressions of various plant forms in these shales would suggest that the purer and more compact body of the coal proper might, near the dividing line, show traces of the tissues and fibers of those or of other and older forms. We have so many coal seams in Indiana, one above another, and each differing from all the rest as much in quality and character as in stratigraphical position, that it would be a matter of great convenience, from both the economic and the scientific point of view, if we could discover even microscopic fossils by which each seam could be identified so soon as a sample could be examined.

Large deposits of diatomaceous earth, or rock, have long been known at various points in the United States, the most noted being in Virginia. As yet none has been found in Indiana of a quality fit for commercial purposes; but it is not impossible that we may yet be successful in discovering a bed of it. At any rate the field for microscopic work in the rocks of Indiana is a large one, and well worth a great deal of attention.

There is yet another special subject to which the thoughtful and investigating minds of students may turn with profit. The Drift clays have not been properly studied with a view to ascertaining their origin. The writer of this paper believes that the microscope alone can settle this question. It will be found upon examination that a good glass of moderate power will disclose in these clays fragments of fossils from which the original location of the contributing rocks can be determined with approximate accuracy. Maurice Thompson, the present State Geologist, has made a long series of observations in this line upon which he hopes to base a report in the future. Such work is necessarily very slow and its details very minute and tedious. It would be a great saving of time and a constant check upon inaccuracy, if a considerable number of competent persons would join in this very important work, and occasionally contribute their discoveries to this department.

ARCHAEOLOGICAL RELICS AND HUMAN REMAINS.

Properly speaking these relics and remains are fossils, and may be treated as such herein. No ancient forms can be of more significance or more weighted with tantalizing suggestions than the stone, and other implements of the prehistoric races of men. I have already spoken of the curious law of perversity which causes persons to store up these relics as ornaments (?) in their private houses rather than contribute them to the upbuilding of a great State museum in the capitol. If all the stone implements, pipes, pottery, copper relics and bone instruments now scattered over the State in the hands of individuals who can make no scientific use of them were given to this department, it would double the value of the museum, while it would not make the donors one cent poorer. There are yet a few mounds, scattered over the State, which might give good returns to investigation. For a description of these and a clear and succinct history of what is known about the so-called prehistoric races of Indiana, the reader is referred to Professor Gorby's able paper in the fifteenth report of this department.

SUB-FOSSIL REMAINS.

Referring here particularly to the skeletons and skeleton fragments of presently existing animal forms frequently found imbedded in our soils, and especially in our peaty bogs, it may be said that such remains are quite interesting and valuable, and will be gladly received in the museum.

They serve as data from which the natural history of Indiana may be written. At present most of the larger forms, and many of the smaller forms, of wild animals (which formerly lived here) are forever gone from our State, and the only certain guide left for us in making up the faunal lists is found in these fossils, since the memories and traditions of men are notoriously unreliable in matters of natural history. Every bone found imbedded in the soil, muck, peat, sand, gravel or clay should be preserved until it can be examined by an expert comparative anatomist, or it should be sent directly to the State Geologist. In England and France, and, in fact, throughout Europe, the sub-fossil remains have received far more attention than in America. Here, because our country is new and in many parts still infested with most of its original animals, we have neglected to collect and preserve the only sure indices of local faunas. It is already too late to make complete amends for this oversight, but a great deal can yet be done to make clear most of the facts necessary to a complete natural history of recent and contemporary life. Indiana can not afford to be behind in this, and it will be well for the controllers of her educational institutions to take early steps toward attracting the attention of students to a field so full of valuable materials likely to soon disappear forever.

The chief object of this paper is to suggest and stimulate investigation and to impress upon the people of Indiana the prime necessity of popular donations to the State Museum. The Legislature never has furnished the Department of Geology and Natural History with a fund sufficient to warrant the purchase of collections; the extensive cabinets now in the museum represent the work of the State Geologist and his assistants since the beginning of the survey, with the addition of small donations by a few public-spirited men and women who have cared more for the general welfare of the people than for their own narrow curiosity or their hope of being able to sell for a paltry sum the objects of merely scientific interest and value.

A vast museum of Natural History and Geology, open at all times to the public, is a center of study whither flock for investigation and reference all the most active-minded and inquiring students in the Commonwealth. It is a place where a liberal touch is given to intelligence and where the profoundest suggestions of nature present themselves in connection with a vast variety of the most interesting and instructive forms of past and present life. It is not mere dry technical science that offers itself and speaks through these exponents of past ages, if we view them with an enlightened vision. In learning the alphabet of terrestrial life, we build the foundation of a practical and keen perception of what are our present needs and our future possibilities. Broad culture and a high civilization give to a people that sensibility to coming generations which is the dividing line between a christian and a heathen influence; but there can be no broad culture, no high civilization, in the true sense, where science is viewed with prejudice and where its results are belittle or denied by the directors and controllers of popular sentiment.

The time was when Indiana was looked upon by those outside of her boundaries as a State given over to ignorance and boorishness, but this reputation is rapidly passing away before the effects of popular education and the liberating influence of increasing wealth and almost unlimited means of intercourse with the rest of the world. It is not too much to say that this department has aided in the good work of showing to all lookers-on the many striking advantages possessed by our State in point of richness of soil, value and quality of mineral products and healthfulness and desirability of climate. Beginning with Brown and Owen and coming down with such able and enthusiastic men as Cox and Collett, together with the large number of learned and able assistants, the department has been the faithful and earnest register and annunciator of the State's material progress from its infancy to the present hour. It should certainly have the support of the people, and in no better way can this support be affirmed than by liberal donations to the museum, and prompt and ample appropriations by the Legislature.

OUTLINE SKETCH OF THE MOST VALUABLE MINERALS OF INDIANA.

W. H. THOMPSON.

The most valuable deposits found in the rock formations of Indiana may be described briefly as follows:

INDIANA KAOLIN.

In the Fifteenth Report of this Department, the State Geologist gave a clear and concise paper suggesting the origin and composition of the kaolin beds of this State. Since then the subject has received a careful re-examination from every point of view, and although the conclusions first arrived at have been very generally maintained, it has been considered proper to record briefly the best possible outline of the subject as it is now understood.

First, to those who have not made chemistry and geology, with their kindred sciences, the subject of careful study, it is necessary to give some cardinal rules governing the dissolution and rearrangement of sedimentary rock formations under the action of water and other natural agents.

Rain water is the greatest destroyer of rocks; the atmosphere comes next. The operation of these forces is two-fold chiefly. Mechanical destruction is brought about by mere gravitating motion; chemical destruction comes on by reason of a motion generated by the subtile action of one substance upon another tending to dissolve, disintegrate and dissipate. On the other hand mechanical reformation is by sedimentary deposit, while chemical reformation is through molecular re-arrangement by the laws of chemical affinity.

A practical example of the mechanical destruction of a rock would be the case of a limestone or a sand stone which, when exposed to the action of rain water, is slowly dissolved and washed away in the form of fine particles. If these particles be afterwards deposited and form themselves into a compact body by the force of their own weight we shall have a case of mechanical reformation.

A practical example of the chemical destruction of a rock would be where a limestone or a sandstone is acted upon by an acid agent causing molecular disintegration. Chemical reformation is the coming together of the ultimate molecules of disintegrated substances by the laws of affinity.

The salts of iron can be taken up in water which, when exposed to the oxygen of the atmosphere, deposits the iron in the form of oxide, as is witnessed by the yellowish sediment of all our chalybeate springs. In a similar way silica is solved by water and afterward deposited in the form of crystals, flint nodules, silicified wood, etc. Lime, alumina, magnesia and many other substances are subject to the same or kindred processes.

Chemically speaking, the kaolin of the Indiana deposits is a silicate of alumina, bearing but slight traces of iron, lime and other substances. For all practical purposes it is a pure silicate of alumina.

It is found underlying the conglomerate sandstone, and occupying the space which otherwise is filled with a stratum of limestone; in other words, it has usurped the place of the limestone. Professor E. T. Cox, formerly State Geologist of Indiana, was the first to suggest that the kaolin owes its origin to the destruction and the chemical reformation of the limestone; but this theory did not go far enough to account for all the elements of the problem. Under the conditions propounded the almost total absence of lime in the clay and the heavy per cer cent. of silica and alumina could not be explained. What went with the lime from the dissolved limestone stratum? Why was it not redeposited on the spot along with the silica and the alumina? Furthermore, whence came such a wonderful amount of the last two substances? In the first place, moreover, the fact arose that here was a deposit of clay entirely filling up the space formerly occupied by the limestone, and since a whole is greater than any of its parts, it was impossible that the limestone had furnished all the material for the clay with all its original lime and iron to spare.

With the above-stated questions in view, the whole problem has been analyzed, and every fact bearing upon it has been scrutinized with all the care possible, more particularly because no feature of Indiana geology has attracted wider attention or given rise to more curious inquiry.

To understand the matter at the outset, let us try to get a view of the local situation as it was before the kaolin beds had begun to be deposited, after which we shall be able to follow the process of deposition.

In the beginning, then, we have a stratum of limestone of a soft and destructible nature, immediately above which lies a massive sandstone formation of coarse grain and loose texture.

Everybody knows that rain-water will percolate easily through massive coarse sandstone, and in this case it did so percolate, and thus reach the underlying limestone which it slowly destroyed, the first step being the bearing away of the lime and iron, these being the elements most readily affected by the water. The residuum now left of the limestone is composed of silica and alumina; meantime the water passing through the sandstone has been taking therefrom silica and alumina, with a trace of mica in a fine state of mechanical division, and bearing them down to the cavity below, where by chemical action they combine with the silica and alumina left over from the destruction of the limestone. Thus, in short, was the kaolin of Indiana made.

The above theory is perfectly borne out by all the facts yet discovered bearing upon it. If proof is asked for in justification of the assertion that water passing through sandstone will take up silica and redeposit it at a lower horizon, we may cite the flint beds found underlying the massive sandstones in so many places. In Tippecanoe County, and in Warren and Fountain counties, are notable examples of these flint deposits, due to the action of water passing through the conglomerate sandstone. In the southern part of the State such deposits lie below many of the carboniferous sandstone strata. Chert or flint nodules and so-called veins occur (in all our limestones) where the silica has been deposited in cavities left by the previous solution and removal of easily destroyed substances. In each of these cases if the alumina had been present we should have had kaolin in the place of flint bodies. As has been shown in another part of this report there are places in the drift formations where the silica and alumina of the bowlder till has been taken out by water and deposited in the form of a white kaolin-like clay often of great thickness. In a gas well of Boone County a stratum of this white clay was found to be over a hundred feet thick. In Kosciusko County a vast bed is reached at a comparatively slight depth underlying the bowlder clay. These drift deposits of so called kaolin bear a heavy per cent. of lime carbonate, and are more or less touched with iron oxide. In some places carbonate of magnesia is a large element of the clay. So it will be seen that wherever water percolates through a formation it gradually removes a large amount of the soluble constituents. Lime goes first, magnesia next, then alumina, then silica, and whenever the two last mentioned come together they blend chemically and form the silicate of alumina, which, in Indiana, has been named kaolin.

In the case of lime taken up by water the redeposit is in the form of chalk, like that which in the northern part of the State is known as lime marl.

The kaolin of Indiana differs from that of many other districts of the world in that it bears very little mica, and no discoverable evidences of having been formed directly from the dissolution of granite or other primitive rocks.

The deposits of kaolin in Lawrence County cannot be mentioned too often. Here lies a practically exhaustless quantity of the most beautiful, pure and desirable clay ever offered to the manufacturer of fine earthen wares, to say nothing of its value in various other branches of manufacture. Next to our coals our natural gas and our building stones these magnificent beds of kaolin will in the future be the greatest source of our mineral wealth.

The only way to build up the varied interests of Indiana is to make the world familiar with our resources. This is not the work of a day, a year, or a decade, but it must come of long, persistent, continuous advertising. It was many years after our coal fields were discovered before the commercial and manufacturing world could be made to believe that any paying coal mines could be opened in this State, and now, after years of reiterated statement the kaolin beds of Indiana are scarcely recognized, so timid is capital and so conservative and reticent are the owners of the valuable mines. It is, however, a mere question of time, patience and persistent energy; such resources are a mighty reserve of wealth.

INDIANA BUILDING STONE.

From Greencastle, in Putnam County, southward to the region of the Ohio River stretches a vast area under which lies the oolitic limestone whose fame as an incomparable building material is beginning to be known all over the country. Within a few years' time the quarrying interests have been developed to such an extent that the superb blocks of oolitic limestone are seen on nearly every railroad in the land, and an immense capital has found most profitable and permanent investment.

This rock is an element of the St. Louis group showing itself in a massive, evenly bedded stratum of homogeneous limestone, of a whitish gray color, whose grain, viewed casually, has the appearance of a rather coarse sand loosely cemented together. Upon careful examination with the glass, however, this grain proves to be infinitessimal shells and shell fragments all bound together by a firm and even setting of lime carbonate. No art of man could construct a mass at once so firm, even and workable, and at the same time so elastic and strong. The stone comes from the quarry soft, tough and easily cut. In a short time it hardens so that it rings with a musical note (like that from a steel bar) when struck with the hammer. A bar of it four feet in length and two inches square may be bent so as to deflect greatly, and when released will spring back to a right line with the promptness and energy of highly tempered steel. Upon being broken the stone parts with a smooth, direct fracture, showing a surprising evenness and continuity of texture with no trace whatever of laminatious seams or changes of structure. The Capitol building at Indianapolis shows the wonderful qualities of this superb stone, and every passer-by may see how beautiful, how massive and how well suited to building purposes it is. Our quarries have made the building one to be proud of, and in turn the building is an imperishable monument to the resources of our quarries.

Geologically the oolitic limestone is very interesting, and its existence is by no means a problem easy of solution. The more it is studied, however, the more it appears to be the result of calcarious sediment deposited at the bottom of a deep trough in an otherwheres shallow sea. The shells of which the greater portion of the rock is composed, are, as a rule, much smaller than the smallest ordinary pinhead; indeed, barely distinguishable under the most favorable circumstances by the unaided eye. These minute shells are cemented together with a cement composed of fine fragment-dust of other shells, and an intermediate setting of pure lime carbonate, which renders the whole mass perfectly homogeneous, elastic and resonant.

The name, oolitic, as applied to this element of the St. Louis group of rocks, is not technically a proper one, but it is sufficiently distinguishing for practical purposes. On the northern verge of the field the limestone loses the oolitic grain in a degree, but it remains, nevertheless, a building-stone of the highest value and beauty. There can be no favoring distinctions made in this report between the various quarries of the region; in every locality examined the stone is simply perfect in its qualities. Doubtless there are exceptions to this general rule, but the careful inquiries of the Department have failed to discover them. It is safe to say that the oolitic limestone quarries of Indiana can challenge boldly the competition of the world. Indeed, the challenge has gone forth already, and, in consequence, the beautiful and indestructible material is reaching all parts of the continent where permanent buildings are being erected. No estimate can be made of the future extent and profit of this great deposit. Time alone can disclose the wealth it holds for the enterprise and industry of our State.

SANDSTONE OF INDIANA.

Wherever the rocks of the lower coal-measures are at or near the surface massive and evenly bedded, sandstones are apt to be found, and among these appear strata of the most beautiful building stone.

From Warren, Fountain and Montgomery counties southward these sandstones outcrop along the dividing line between the coal-measures and the sub-carboniferous rocks. In consistency, the sandstones of the Chester group are quite often very similar to those of the lower coal-measures, but the latter are more apt to be homogeneous, elastic and durable.

Geologically, all our sandstones mark the sites of ancient shore-lines, and the vegetable fossils found in them show that they are the flotsam and jetsam of seas more or less shallow and stormy. Extinct species of shore plants and marsh grasses are found in fragmentary and obscurely preserved traces. The more plainly marked species represented by broken and flattened stems of *calamites* are found embedded in the coarser grained and loosely cemented parts of the rock, while the vague markings of the obscurer species are found usually in the more compact and even-grained strata.

The composition of our best sandstone is quartz in the form of irregular fine crystal particles cemented together with great evenness and firmness. It comes out of the quarry soft and easily workable, but soon hardens to the consistency of the best elastic and resonant building material. I have seen it cut from the outcrop with a common ax, and readily hewn into any desired shape; in a few days it had set and become so hard that a bush hammer would ring upon it as if struck upon bell metal, emitting sparks freely. The hardest tests have shown the qualities of this stone to be surpassed by no other sandstone in the world, and it is a matter of surprise that it has not been more used. No doubt the future will see the development of this valuable and beautiful source of wealth.

INDIANA COALS.

No formal report upon our coal deposits is needed here unless it could include the results of a resurvey of the field, a thing much needed, but which has been impossible under existing circumstances. Practically inexhaustible, easily mined and of the very best quality, our coals are the most desirable of their kind in the world. The number of workable veins is remarkable, and the coal itself varies in character from a pure cannel coal to what has come to be known as "block coal" all over the country. While we have no anthracite, the extraordinary quality of the block coal sets it above every other bituminous variety. The mines of this coal in Clay County afford immense quantities and are worked with great skill by the operators. Still it must be said that as yet our coal fields are in the early infancy of their profitable development, and it requires no gift of prophecy to foresee what coming years have in store for the owners of our exhaustless mines.

At present the equilibrium of manufacture is disturbed by the advent of natural gas as a great new factor, and it will require some time and experiment to determine just the limit between it and coal. It is natural that for a season the rush should be to the gas fields pell mell without any careful weighing of the facts in advance. One thing favors coal in this race for supremacy: we know that it is practically inexhaustible, while the supply of gas must be left in doubt with the weight of probability on the side of a comparatively early failure. The form of our fuel may change permanently, but it is to our coal beds that we must look as our base of permanent supply, for a long time to come.

When it is borne in mind that we have a coal area of almost seven thousand square miles, under which there are in many places several successive workable veins, the enormous value of the deposit becomes apparent.

The reader is referred to the Fifteenth Report of this Department for a geological sketch of the coal measure rocks and a concise exposition of the theory touching their development.

Coal of excellent quality, and often in inexhaustible quantity, is found in the following counties of Indiana: Posey, Vanderburgh, Warrick, Spencer, Perry, Crawford, Gibson, Pike, Dubois, Knox, Daviess, Martin, Sullivan, Green, Clay, Owen, Vigo, Parke, Vermillion, Fountain and Warren. In many localities the mining is by the process known as "drifting," but the larger part is by a system of shafting. The mines of Indiana are by law kept well ventilated and drained.

INDIANA IRON ORES.

Compared with those of other parts of the country, the deposits of iron in Indiana are insignificant and inferior, though we have some beds of exceedingly fine ore. Most of the swamp region of the Kankakee country has considerable deposits of bog iron; these were formerly worked successfully at several points, but at present they are abandoned practically. Nearly all the coal-measure counties have iron ores in workable quantities and of good quality when mixed with foreign ores, and the presence of lime and coal renders it practicable to manufacture a good grade of iron well within a paying margin of profit. In Clay and Vigo counties especially furnaces have been quite successful, but this has been due much more to the excellent coal near at hand than to any local deposits of ore.

INDIANA LIME AND CHALK.

Fine limestone for burning into lime is found in nearly every neighborhood where the stratified rocks are outcropping. From as far north as Monon and Delphi southward to the Ohio River, kilns have been erected and the manufacture of lime made very profitable. The product in most instances is extra fine and very popular in the market.

As yet the manufacture of cements has not been given the attention which the prospects of success would warrant. Among our widely varying deposits of limestone every quality is to be found, from a practically pure carbonate of lime down through all the shades of impurity to the silicious and aluminous shales that bear a minimum of calcerous matter. Special investigation would doubtless disclose to the prospective manufacturer, at one point or another, just the material suited to his particular need.

Professor Gorby, in his report on the geology of Washington County, describes immense deposits of cement rock occurring at several places in that county. Indeed, it is safe to assume that hydraulic cements can be successfully manufactured at many points in Indiana.

The survey has not yet reached the northern counties of the State wherein are found the considerable deposits of chalk, or so-called lime-marl, but from specimens of this substance examined recently it would appear that by the addition of the proper amount of clay a fine hydraulic lime, or cement, might be made from it.

Wherever beds of magnesian limestone are found the rock may be examined and tested with a view to determine its hydraulic qualities. A simple test may be made with acid. If the residuum after dissolving is a jelly-like silicious mass it is evidence that the stone has hydraulic qualities.

The best combination of substances for hydraulic purposes would be nearly this:

Lime	56
Alumina	36
Oxide of iron	8

The oxide of iron is of no value, but is rarely absent from the impure limestones sought after for the manufacture of hydraulic lime and cements.

Recently attention has been directed to our limestones in connection with the manufacture of Portland cement, but as yet little progress has been made, though every fact would indicate the certainty of success under a properly directed experiment. The agent of a German company has been prospecting with a view to locating a manufactory where the presence of proper materials and the best facilities for transportation are to be found. It is hoped that the effort will end in the success which would insure the establishment of a new and paying industry in Indiana.

The Portland cement of England is made by calcining together, in certain proportions, chalk and the clayey mud of the river Thames. It is scarcely to be doubted that our chalk beds could be utilized for the same purpose successfully after a little experiment necessary to discover the proper formula for the addition of clay. In connection with the oolitic limestones there are various grades of magnesian and clay strata which offer very promising subjects of study with this object in view. It is to be hoped that the impetus given to manufactures by the discovery and development of our fields of natural gas will add strength to the movement toward a general development of the mineral resources of the State.

When the survey reaches, as it soon must, the area in which lie the chalk deposits, an exhaustive examination of these will be made with confidence that a new and very rich element of wealth may be developed in time. The manufacture of farm and garden fertilizers will soon claim attention in this State, and these chalk deposits may prove to be immensely valuable in this connection.

Geologically considered the chalk beds of Indiana are exceedingly interesting on account of the difficult problem arising out of the nature and mode of their deposit. To find a vast lenticular mass of almost pure carbonate of lime lying in a basin scooped in the bowlder clay, and covered with a heavy deposit of swamp mud, presents a question not as easily disposed of as might at first be supposed, nor is it my purpose to attempt its solution at this time. Doubtless the main element of the problem lies in the fact that water surcharged with calcarious matter will, when perfectly still, let fall the overweight of its burden, which will at once sink to the bottom. The evaporation of water will gradually overcharge the residue, because the entire body of foreign matter is retained, while the body of the water is shrinking. Still there are other elements of difficulty connected with the inquiry which appear at present scarcely reconcilable to any general scheme of solution. The present chief of this department has suggested a theory which may prove to be the correct one, namely, that a long period of drouth, a rainless era, followed the withdrawal of the glaciers and that a season of evaporation must have been accompanied by a vast amount of sedimentary precipitation. This fully accounts for the purity of the lime deposits where otherwise we should have it mixed with all manner of clayey washings from surrounding surfaces affected by rain and superficial drainage. The author of this theory further suggests that much of the precipitation of chalk may have gone on while the water was covered with ice, and that the deposits were thus protected from the invasion of surface washings and other alien matter.

OTHER MINERALS AND ORES.

Natural gas, for the reason that it is fully treated in another part of this volume, will not be more than mentioned here. The reader is referred to Professor Gorby's able and comprehensive paper.

Gold is found in the form of minute spangles and scales in many drift areas, but nowhere in this State is there a quantity sufficient to make a search for it profitable in any degree. Traces of silver have been discovered in some of our limestones, and here and there small quantities of lead have been reported. Copperas exists in considerable deposits in various parts of the southwestern region of the State. Iron pyrites is plentiful. In all the coal region fire-clays of most excellent quality abound, and in nearly every county of the State good brick and farm tile clay is plentifully present. Indeed, it may be said with confidence that few States in this Union are blessed with a richer or more varied wealth of mineral deposits than is vouchsafed by the as yet undeveloped resources of Indiana. When the population of our State shall have doubled and trebled itself the exigencies of an advancing civilization will enforce the most economical and scientific use of all this hidden treasure. The labors of this Department from year to year have stimulated a wholesome spirit of inquiry and experiment, so that in our schools and colleges the practical study of geology and its kindred sciences has become a prime favorite with many of the brightest and most energetic students.

The future of mineralogy and metalurgy doubtless depends much upon the simplification and perfection of methods for reducing ores and cheapening the manufacture of refined metals. The common clays of the earth are rich with a metal which, if it could be produced and rendered as cheap as iron, would revolutionize, in a large degree, the whole world of manufacture. This metal is *aluminium*, which occurs in the form chiefly of silicate of alumina, although the anhydrous forms, like the crystals, ruby, sapphire and corundum, appear in certain parts of the world and are much sought after for gems.

It is admitted by men of science everywhere that aluminium is almost the ideal metal, barring the difficulties attending its production, for a practically countless variety of economic purposes. In the first place it is extremely light, having a specific gravity, even when condensed by hammering, of only 2.67, and then its malleability, its ductility and its strength render it singularly desirable. As yet no process has been discovered for cheaply separating it from the clay and aluminous shales in which it is so abundant. Here is a problem for the genius of our time. What young man will cover himself with glory and send his name forever down the future by overcoming the difficulty which bars this greatest of all metals away from the eager hands of the nineteenth century people?

One of the highest functions of our educational institutions should be to keep problems like this constantly before the eyes of the young, energetic and ambitious students who will be easily persuaded to devote themselves to systematic and patient experiment, having in view the attainment of a crowning victory which of itself would give to our civilization the greatest impulse it has received since the application of steam to commerce and manufacture. An investigator of Edison's stamp would find a field of wide possibilities in subduing a problem of such importance; nor is there any good reason for believing that the undertaking offers greater resistance to genius than did the electrical problems so readily mastered by the efforts of Edison.

The manufacture of alum and sulphuric acid might, it seems, be made quite profitable at many points in Indiana, and attention can not be too often called to our deposits of aluminous clays and shales.

GOLD, SILVER AND PRECIOUS STONES.

It would seem scarcely necessary to occupy a page of this report with a statement of the fact that there is no gold or silver to be mined in paying quantities any where in Indiana, and yet as many as three hundred letters have been answered in one year by this department on this subject. Scarcely a day passes that does not bring to the State Geologist, a package, large or small, whose contents can be described as "fool's gold," or pyrites of iron, accompanied with the inquiry: "Is this gold?" or, "Is this silver?" This phase of the matter is not, however, the most serious one. Designing parties, with a view to speculation, have been creating excitement in a number of localities by claiming that rich deposits of precious ore have been found. No year passes that does not see our newspapers giving wide circulation to these malignant and demoralizing untruths. There is no geological formation in Indiana, within less than two thousand feet of the surface, in which gold or silver could possibly exist in paying quantity. Every report to the contrary has been based upon either ignorance or fraud. Only a year ago great excitement was created all over the Southern part of the State by the loud claims of interested persons touching vast deposits of silver ore said to have been found. Now, if the people were as willing to believe science, when it speaks, as they are to believe charlatanism when it makes its preposterous statements, there would be little trouble about preventing nearly all the gold swindles and silver frauds of the kind under consideration. The office of this department is always open to the inquirer, and every question relating to the mineral deposits of Indiana will always be answered promptly and without prejudice or favor; but it should be, if possible, settled once for all that any and every person who reports the discovery of gold or silver deposits in this State, is either wofully ignorant or wilfully dishonest. So great and so glaring have been the frauds perpetrated by would-be speculators and their coadjutors, and so numerous have become the inquiries connected with this subject that it appears absolutely incumbent upon this department to put an end to the whole matter, if possible.

If every one who receives a copy of this report will read this paper and then ask the school teachers of his neighborhood to explain its contents to the students, we shall soon get rid of these excitements and swindles, than which nothing could be more demoralizing to the public mind.

The following simple statement will make clear to any mind why it is preposterous to believe for one moment any report, no matter who makes it, which locates a gold mine, or a silver mine of any value in Indiana.

GOLD.

In its native state, gold is found, if in place, connected with and usually woven into the substance of the crystalline primitive rocks, the traps or trachites and the transition rocks. In other words, gold is found in rocks which far underlie all the limestones and shales of Indiana. To cut down to the primitive or igneous rocks in this State in the shallowest place would require a well of at least three thousand feet in depth; probably the distance would be much greater at the most favorable point. But even after the old rocks have been reached and they never yet have been in Indiana, the probability of touching a gold-bearing area would be absurdly small. Gold is often found in great quantity in the Silurian and superior rocks, but only where these rocks have been transformed by heat. The sedimentary rocks of Indiana have not been transformed by heat, therefore there is not the first condition for the presence of gold. What is termed by geologists *metamorph is*, always accompanies the presence of gold in workable quantity in stratified rocks. This metamorphosis has been brought about by a degree of heat sufficient to change the structure of the rock. Now, in Indiana, the only metamorphic rocks nearer than 3,000 feet of the surface of the ground are mere bowlders and fragments found in the drift. Hence it is simply preposterous to think of finding gold in the stratified rocks of this State, and the delusion should be driven from the minds of the people at once and forever.

But gold is often found in dykes or up-flows of trap, trachyte and other ancient rocks, which, in a molten state, or other somewhat fluid condition, have been sent up through rents in superior strata. No such dykes exist in Indiana, nor are there any quartz veins or gold-bearing formations of any sort whatever. The only rock disturbance in Indiana is a low irregular upheaval across the central and northern parts of the State, and this is so slight that it has not lifted any of the archean rocks to within 3,000 feet of the surface.

When gold is not in place, or in other words, when it has been freed from the rocks by the action of water or other disintegrating forces it may be found in the clays or sands of alluvial deposits. Mere traces of gold n the form of minute scales or flakes may be found in such deposits in Indiana, but no man, even by the most prudent management and the most faithful labor, can average one dollar a day washing for gold in the richest sands discoverable in this State, and it would be a boon of incalculable value to many an overstrained imagination if all the newspapers of Indiana would set this truth before the people in the strongest terms, and furthermore stamp as false and fraudulent every reported gold discovery in our State from this on to the end of time.

SILVER.

In a general way, what has been said of gold may be said of silver; but the latter is never found in notable quantity save in the body of the metal-bearing rock where it is usually associated with gold, copper or lead, and other and baser substances. The volcanic and primary rocks bear silver, but most of the extensive deposits in America are "pockets" in a disturbed and broken limestone formation. If found in Indiana at all silver would be in a galena ore, most probably, and there is not within the State the slightest approach toward such a deposit, and if found here the galena would, we may assume, have but a trace of silver along with the lead, so that in any light we may sensibly view it, there is no more probability of a paying silver mine in Indiana than there is of a paying diamond mine.

Competent chemists have been defrauded into making assays of ores, sometimes quite rich in silver, falsely said to have been found in certain so-called mines in Indiana. It would be wrong for the public to blame the assayer; but it is to be hoped that in the future no shares in any so-called mine of silver or gold in this State can be sold at any price. Indiana is rich in minerals. She has iron, coals, clays, marls, glass-sands and building-stones; but, let it be repeated until everybody knows it, *she has neither silver nor gold.*

PRECIOUS STONES.

Another delusion with which thousands of very sensible people are beset is the precious stone delusion. It is a pathetic fact that many persons are monomaniacs on this subject to such a degree that they spend a great deal of time delving nervously and surreptitiously in gravel beds and sand deposits, pouncing upon every shining bit of quartz-crystal or feldspar which chances to meet their eyes. Since I have been State Geologist a number of cases coming under my observation may be taken as indicative of a class. Men and women of average intelligence bring a collection of ordinary crystals (usually water-worn pebbles in form) to the office and, in the most secret and impressive way, exhibit them, evidently expecting to be told that a priceless value attaches to them. Now, if this were mere inquiry there would be nothing unusual about it; but, in a considerable number of instances the gnawing hope of finding something precious has eaten into the imagination to such an extent that it has become a monomania. It is a great pleasure to impart information, and it is not particularly annoying to satisfy mere idle curiosity, but when it comes to dealing with unscrupulous persons who "salt" limestone with silver ore, or when a placid maniac besets one's life with flint pebbles for a series of years, it has a tendency to make one wish that practical geology were taught in the common schools. As an instance of the would-be shrewd tricks which have been attempted in this connection, I may mention the act of a man who at the time no doubt thought that he should "surprise the authorities" in a great way. He came to me with the usual handful of small crystals of quartz, feldspar and calcite, and demanded information as to their value. I glanced over them and answered that they were utterly worthless. A gleam of absolutely malignant triumph shown in his eyes as he picked out one of the crystals and held it up. "You're a beautiful geologist!" he cried. "Don't know even a *cut diamond* when you see it!" He was not aware that I had noticed, at the first glance, a setting taken from some cheap imitation-diamond ring. It was not even rhinestone—simply cut glass, and not of a very fine quality at that!

Indeed, it would be a very curious and most interesting study if a record of the many instances like the above were kept in this office. It would show that there is great need of popular enlightenment upon the simplest and most obvious facts in nature. Such a condition of things is the only excuse for inserting here the reasons why precious stones are not to be looked for in Indiana.

DIAMONDS.

It would appear to be most probable that diamond is the result of heat or of some other metamorphic force, and that wherever found it can be immediately or remotely traced to volcanic or eruptive action which has thrown it to or near the surface. Where it is found in alluvial deposits its presence is due to the disintegration of diabase or some other and kindred igneous rock whose residuum has been brought there by water currents. Nowhere in Indiana is there any formation showing even the remotest resemblance to diamond-bearing rock. Four-fifths of the State's area are covered with drift to a depth of from ten feet to four hundred feet, under which lie the stratified rocks of Silurian, Devonian and Carboniferous ages. Nothing like a dyke or igneous vein is anywhere discoverable, nor are there any clays referable to the decomposition of igneous or metamorphic rock. Therefore, to hunt for diamonds in Indiana is simply ridiculous, the last refinement of folly. It is possible that within the immense mass of our drift there may be a few stray bits of the precious crystal brought from far northern volcanic fields by the glaciers, but to look for these would be as hopeless and senseless an act as it would be to spread a butterfly net with the hope of capturing a meteorite.

EMERALDS.

There are no emeralds in the Indiana geological formations. Some pretty pieces of allophane, clear and of a pure green color, have been found in the body of our kaolin beds and in our flint deposits. Persons have believed this to be emerald, and with little show of argument, on account of its color and clearness, and, furthermore, because it is found so often in aluminous deposits. Emerald is a silicate of alumina colored with oxide of chromium. Allophane when green owes its color usually to oxide of copper. Emerald is a regular crystal, occurring in six-sided prisms; allophane, as found in Indiana, is amorphous, filling interstices in flinty formations, or lining irregular cavities in kaolin. There is not the slightest probability that emerald will ever be found in Indiana.

GARNETS.

Coarse, worthless garnets may be found occasionally among the drift gravels of Indiana, but the gem garnet is not present. Most of the red crystals found are feldspar from broken up granite brought down from Canada by the glaciers. It is sufficient to say that there are no valuable garnets to be found in this State, and search after them is labor thrown away.

JASPER, AGATE, TOURMALINE.

None of these possessing any value is found in Indiana. Stones often brought to this office for examination, and thought by the possessors to be one or another of the precious crystals, turn out to be quartz (either clouded or tinted) worn by the action of water.

OPAL.

There are no valuable opals in Indiana. A lady brought to me for examination a small fragment of coarse granite, smoothly water-worn, in one corner of which was a crystal of quartz that gave forth beautiful irridescent gleams when turned in the light. The quartz had a yellowish cast, and its resemblance to opal was quite striking. The flashes of color were due to cracks in the crystal's substance breaking up the light and reflecting it prismatically. Bits of "opalized wood" are found in the drift, but these are of no value.

SAPPHIRE.

Nothing at all closely resembling the gem sapphire has been found in Indiana. Many pebbles of pink feldspar and rosy quartz have been brought to this office and exhibited as red sapphire (rubies), but the bearers were at length convinced that, after all, their pretty little rolled crystals were of no value, and they went away disgusted, but not discouraged to continue their fruitless poking in the gravel and sand.

TOPAZ.

Crystals of an almost colorless (very faintly smoky) tint and unimportant in size, were shown me as having been found in a gravel bed of Tippecanoe County. One of these, for about half its length, was pale blue and much resembled a topaz; but no amount of friction could make it electric in the least. There is no formation in Indiana wherein topaz can be expected. A stray crystal might possibly be found in some granite or trachyte bowlder, but it would be worthless when found.

In conclusion, there is no true gem stone to be found, high or low, anywhere within the limits of Indiana, and the only way by which an Indianian can remain in this State and obtain these beautiful and precious crystals is to work hard, earn the money and then buy them. A like statement is true touching the acquisition of gold and silver; the only method of obtaining these from the earth in this State is that of steadily and persistently following the plow. Every person who claims to have discovered in Indiana mines of precious metal or deposits of valuable gem-stones should be treated with the utmost caution. He is dangerous, if he is not ignorant, and if he is not crazy he soon may be, for that way madness lies. Bnt let it be remembered that every citizen of Indiana has the right to send to the State Geologist samples of any substance he may discover and inquire as to its value. Such inquiries are always gladly answered, and it is to be hoped that they will continue to be made. It is by such investigations that the truth is to be reached touching the mineral deposits of the State. Although Indiana has no gold, or silver, or precious stones, she has a wonderful variety of valuable minerals out of which great wealth will flow in the near future.

THE FORMATION OF SOILS AND OTHER SUPERFICIAL DEPOSITS.

In the Southern and Southwestern parts of Indiana the soils, when not alluvial, or lacustrine, are residuary, formed by the disintegration of stratified rocks either sandstone or limestone. In the Drift region proper there is no residuary soil, the glacial deposits showing superficial loams, modified loëss, vegetable mold and peaty formations.

Most of our black prairie soil, which is so deep and so remarkably fertile, has had its origin at the bottom of shallow sheets of fresh water, in which sphagnous growths and vast masses of aquatic grasses and weeds have decayed year after year for centuries. In many places this soil is so peaty that in very dry weather it will burn with a slow, hidden fire. I have seen wells that showed a section of nearly twelve feet of this almost jet black deposit. Deep drainage and careful tillage give the best possible results with this land, especially in corn and grass. It has been a question, much discussed, how the carbonate of lime, in which much of the prairie soil is very rich, has been deposited throughout the mass. Upon examination I have found that where the soil approaches a black loam in consistency, the lime is in the form of marl or chalk blended with very fine sand, like the deposits often found at the bottom of shallow ponds fed by surface drainage from calcareous drift. Areas of this description usually are partly or wholly surrounded by what is called "barrens;" that is a region of low clayey or sandy knobs, overgrown by stunted oak trees. It is from the "barrens" that the sand and lime have come down to the lower surface, in cases of this sort; but where we find a calcareous loam covering a wide prairie which has no barrens, we are left without our argument. I have concluded that all the extensive shallow lakes, once so common on our drift surface, were subject to violent storms, since they were without any surroundings tending to break the force of winds, and that consequently the sediment of vegetable matter constantly accumulating was often stirred up and suspended in the water, which, as it was dashed about, took up portions of the clay basin in which it was inclosed, and thus disseminated the sand, gravel and lime through the vegetable matter. This action may be observed now, in the windy season, by any one who will take the trouble to note the changes in the bottom of a shallow pond after each gale. Doubtless the wind storms during the period between the final retreat of the glaciers and the return of vegetation of the larger kinds to the drift area, were much more frequent and powerful than now.

The action of rain-water upon limestone is well known; as the rock is disintegrated the lime is taken up and held in suspension until it is precipitated in the form of chalk, or "marl," as it is popularly called. The bowlder clay in which all the lakes and ponds have had their basins, is calcareous, in a greater or less degree, and from it the carbonate of lime has been taken up by surface water and borne into the reservoirs where it has finally found its way into the silt and vegetable deposits at the bottom. The more peat-like soils have very little calcareous matter in them, and, consequently, are less fertile.

Oxide of iron, in various forms, is plentifully distributed throughout the black prairie soils; in some places it is found as bog ore which has been deposited by water, surcharged with salts of iron, welling up from the clays beneath. What are called "spouty" places, where chalybeate springs come to the surface, are often rich in bog ore; the iron salts solved in the water are oxidized upon coming in contact with the air and are precipitated in the form of oxide of iron, which gradually accumulates in concretionary bodies of a dark brown color sometimes covering many acres. In the region of the Kankakee River these iron deposits are quite frequently observed.

What has been said of the mode of formation of the black prairie soils may also apply to the black soils of our timbered lands. The most casual observer will note that in our burr-oak swamps there are low knobs and swells of white or bluish clay breaking through the black earth; upon these clay swells the white oaks grow, while down in the little "mucky" baisins grow the burr oaks. The black soil in these burr-oak basins and swales has been formed by the deposit of vegetable matter. All the leaves and mold of the forests are washed by rain and blown by wind down from the highest to the lowest places, where in time they form the black muck-like soil. When well-drained the burr-oak swamps of Indiana are incomparably fertile.

What has been named by some of our geologists "modified loëss" is a grayish brown or reddish gray soil capping the higher and dryer areas of our drift. I do not recognize this as a true lacustral formation; indeed, it is doubtful whether lake water ever had anything whatever to do with its deposit. It would be better to name it modified drift matter, and to refer its origin to broad and gentle currents of water flowing away from the retreating glaciers. Everywhere I have found huge bowlders stranded on these deposits, as if dumped there by icebergs. The assorting power of water is capable of modifying the drift substance in so many ways that it can not be deemed that it may have produced the so-called loëss. Doubtless where fresh water shells are found in the body of the deposit we must refer it to lacustral or fluviatile origin; but I have not yet been able to find any such organisms in the "modified loëss" of middle and northern Indiana.

The red and brown clays of the drift resemble very closely the residuary clays of Kentucky and Tennessee, but upon examination they are found to be a modification of the blue bowlder clay chiefly by oxidation and the action of rains and frost. Wherever the surface clays of the drift have been highly charged with comminuted limestone, there has followed a disintegration, the carbonate of lime being freed by the action of rain water and the iron being solved by oxidation, from which has resulted a fine, light loam-like soil colored by the oxide of iron. Under this soil in many instances we find heavy deposits of gravel and sand, and the timber growth upon it is usually tulip (poplar) and white walnut, sugar-tree and black walnut, indicating warmth and perfect under drainage.

Where the face of the ground is rolling the flow of surface water controls the deposition of soil, the deeper and richer formations lying always in the lower areas, while the higher surfaces are more or less denuded of vegetable fertilizers. These washed lands are usually looked upon as unfertile, but an intelligent application of the tile drain to the stiff, dead clay soil will aerate it, oxidize the limestone contained in it and soon render it very productive. Thus the very lands which appear to be best drained by nature most need artificial drainage. Indeed, there is scarcely an acre of land, high or low, in all Indiana, which would not be benefited by a system of under drainage. The two words *aeration* and *oxidation* should be familiar to all farmers. The soil must have air and the mineral and vegetable substances in the soil must have a chance to oxidize. Deep and many drains and deep and frequent plowing are the means of attaining to this end. There can not be too many drains, there can not be too deep or too frequent plowing.

The superficial deposit, locally known as "lime marl," which is found in basins of the drift, has puzzled geologists not a little, its peculiar structure and order of formation offering the following questions:

1st. Whence came the lime?

2d. How was it transported?

3d. What caused its deposition?

4th. Why is it so free from vegetable matter and other foreign substances?

I have given the matter careful investigation, and without going at this time into any minute details of discussion, it seems to me that I can answer the questions seriatim as follows:

1. The lime has come from the body of the drift mass.
2. It has been transported by water in motion.

3. Its deposition has been by simple precipitation, or sediment action, after the water has become still in a basin.

4. It is free from vegetable matter because there was no vegetable matter near by where it was deposited.

Now when I say that the lime has been transported by running water, I do not mean *surface* water; but I do mean water percolating through the drift substance and rising in the basins where it is to let fall its surcharge of carbonate of lime.

Most of the small lakes now existing in Northern Indiana are fed mostly by springs whose water brings up a large amount of lime. Subsequent evaporation causes the precipitation of the carbonate. Analysis shows that these chalk or lime deposits carry a considerable quantity of free silica in the form of very fine sand which has been brought up by the spring streams. In one of the gas wells at Lebanon, in Boone county, the drill at a depth of about two hundred feet in the drift struck a deposit of white silicious clay nearly two hundred feet in thickness, which bore in its composition twenty per cent. of the carbonate of lime. At Lake Maxinkuckee a flowing well brought up a milky-looking fluid which proved to be a thick solution of a kindred clay. I mention these facts to show how easy it is for springs arising out of calcareous deposits to bring up the substance which, when precipitated, will form clean beds of chalk. Calcareous tufa is deposited in the same way by water seeping out of limestone formations.

Superficial mounds and ridges of gravel and sand have been formed by one or the other of two forces: water-currents and floating ice-bergs. When the former have been the force no large bowlders will be found in or upon the mass; but when the latter have acted there may be immense bowlders lying high and dry on the very highest points of the formation. A careful examination will rarely fail to disclose the agent to which any particular deposit is clearly referable. In cases where water-currents have assorted and heaped up the gravel the direction of the flow may be detected by the relative positions of the coarse and the fine material, the former always lying up stream from the latter, from the fact that light material is moved farther than heavy, the same current acting upon each. Where a huge iceberg, loaded with bowlders, gravel and sand, has stranded and melted, its burden will be found laid down in a heap, the mass unassorted. But it is only in favored spots that this last-named feature is observable; for the action of winds, rains and frost has destroyed the strongest outlines of the drift wherever it has been afforded free application to the mass. Here and there, however, a fine example remains. One a little east of Crawfordsville, in Montgomery County, on the south side of the I., B. & W. Railroad, shows its origin perfectly.

Indeed, when once we admit that our drift mass is due to glacial action, we are forced to the conclusion that many curious effects are due to floating icebergs borne along by currents flowing away from the melting glaciers. Of course the highest parts of the moraines would form the most effective barrier to this current, and it would be there that the icebergs would strand and finally melt. Hence it is that most of the peculiar gravel knobs and ridges are located on the highest points of our drift areas, while the presence of immense bowlders lying quite upon the surface of these apices can be accounted for on no other hypothesis than that they have been transported by ancient ice-ships whose cargoes fell where the vessels melted. Some of these icebergs must have been of almost unimaginable size in order to bear the tremendous loads cast down by them all over the drift area.

The gravel mounds, often mistaken for ancient Indian works, which are found on the terraces and in the bottom lands of our rivers and rivulets, are not glacial formations, but owe their origin to a time when the streams upon whose banks they rest were much larger than now, and when thei currents had power to heap up these curious deposits.

Over large areas in the northern part of the State vast bodies of sand, very fine and of a light buff color, heaped in hillocks and ridges, are due to the action of wind. The sand has been thrown ashore by Lake Michigan, at a time when its waters covered a far larger surface than now, and thence it has been transported by the prevailing winds southward and eastward to its present situation. There is reason to believe, and I venture to assume provisionally, that the result of a careful survey of the region north of the Kankakee River will show that at a very recent geological date Lake Michigan had an inlet or large estuary reaching southeastwardly from its present southern boundary, and covering a considerable portion of Northern Indiana.

REPORT UPON THE GEOLOGY OF DEKALB COUNTY.

BY CHARLES R. DRYER, M. D.

DeKalb county was organized in 1837 out of territory then belonging to Allen and Lagrange. It includes nine full Congressional townships and three fractional, its length east and west being twenty and one-half miles, and its breadth north and south eighteen miles. Its area is 3,690 square miles, and its population 20,225. It contains within its limits four considerable towns: Auburn, the county seat, Waterloo, Garrett and Butler. It is bounded on the east by Ohio, on the south by Allen county, on the west by Noble, and on the north by Steuben. The civil township originally corresponded to the Congressional in the following manner:

Tp.	*Range XII.*	*R. XIII.*	*R. XIV.*	*R. XV.*
35.	Fairfield.	Smithfield.	Franklin.	Troy.
34.	Richland.	Union.	Wilmington.	Stafford.
33.	Butler.	Jackson.	Concord.	Newville.

The two southern tiers of sections in Richland and the two northern in Butler have been taken to form the civil township of Keyser, but references in this report will be to townships as given in the table.

The whole county is covered by a heavy mantle of drift which borings show to be in some places 400 feet thick, and it is probable that the rock nowhere approaches nearer to the surface than 200 feet. Physically, the county belongs almost wholly to the Wabash-Erie region, a full description of which will be found in the accompanying report upon the geology of Allen county. Except a small portion in the northwest corner it is drained by the St. Joseph river, and its tributaries.

The lowest point in the county, at the southeast corner, is about 775 feet above sea level; the highest, near the northwest corner, has an elevation not far from 1,000 feet. Between these limits the relief of the surface consists of three parallel ridges with two intervening valleys, which cross the county in a direction nearly northeast and southwest. It is as if some gigantic plow had turned three furrows, the northwestern one being a "back furrow" thrown up against another turned from the opposite direction. To a certain extent this comparison is a simple statement of a fact, but the whole fact is not quite so simple. The Van Wert and Hicksville ridge, which marks the shore line of a body of water elsewhere described as the Maumee Lake, touches the county at the southeast corner. Between that and the St. Joseph River lies the first great ridge, five miles wide and with an elevation at the summit of 76 feet above the Hicksville ridge, and of 60 feet above the river. It occupies the township of Newville and portions of Concord and Stafford. West of the St. Joseph a second great ridge, about eight miles wide, occupies the townships of Troy, Stafford, Wilmington, Jackson, one half of Union, and the greater part of Concord and Franklin. It is bounded on the west by the valley of Cedar Creek, and the prolongation of that valley from the northern part of Union to Aldrich Lake on the north line of Franklin. The crest of this ridge, within a mile or two of its western border, is about 125 feet above the St. Joseph, 60 feet above Cedar Creek, and averages 65 feet higher than the first ridge. A third ridge, still more massive and elevated, occupies the townships of Fairfield, Smithfield and the greater part of Richland, having its watershed near the northwestern border of the county and its longest slope in Noble, Lagrange and Steuben counties. Its summit is probably nowhere less than 1,000 feet above the sea, and from 100 to 150 feet above Cedar Creek Valley.

The eastern border of this ridge can be distinctly traced along the road from Hamilton, Steuben county, to Waterloo. On the road from Auburn to Corunna it is marked by a sharp rise at the southwest corner of section 13, Richland, whence it continues as a well defined bluff to the southwest corner of section 27, thence southward along Little Cedar Creek. Cedar Creek valley therefore increases in width from one mile at Aldrich Lake to five miles in Butler township.

The surveys of northwestern Ohio by Gilbert and Winchell, of the whole territory north of the Ohio & Missouri rivers by Chamberlain, and of northwestern Indiana by the present writer, show that these ridges are glacial moraines and a portion of a vast morainic system extending from Cape Cod to Dakota. The last continental ice-sheet which covered northeastern North America was divided along its southern border into numerous lobes or tongues which projected many miles beyond the main mass. One of these, after scooping out the bed of Lake Erie, thrust itself up the present Maumee Valley and down the Wabash nearly to Illinois. In its progress it slid over, pushed along and plowed up the debris left by former ice sheets, and when compelled by a slowly ameliorating climate to retreat, it added its own load of bowlders, gravel and sand to the previously accumulated mass. At the same time a smaller tongue of ice was pushing from Saginaw Bay southwestward through Michigan to northern Indiana. It was crowded upon by a much larger mass which passed southward through the bed of Lake Michigan. The Saginaw Lake was thus hemmed in between mightier antagonists; but it was sufficient to offer considerable obstruction to the Erie Lake, which was thus prevented from spreading out to the northwest.

Between the two a broad ridge of earth was piled up several hundred feet high to form the hills of Steuben, Lagrange, Noble and northwestern Dekalb. This is the "back furrow." The two ice lobes acted to some extent like road scrapers, but a large part of the material was carried by the scrapers themselves upon their upper surface and frozen into their mass. When the ice melted this portion gradually settled down or was dumped in heaps upon the top of the ridge. Thus originated the "hog backs," dome-shaped and conical hills, "potash kettles" and lake basins, so numerous and characteristic of the region. The whole ridge extends from Sanilac County, Michigan, to Cass County, Indiana, and is called *the Saginaw-Huron interlobate moraine.*

The retreat of the Erie glacier was interrupted by several periods during which the severity of the climate was such that the outer edge of the ice maintained its position in spite of melting. It was like the advancing column of an army, the head of which, on reaching a certain point, is constantly swept away by the fire of the enemy, while the loss is supplied by new forces from the rear. The ice was continually pushing forward, but could not pass beyond a certain line because it melted as rapidly as it advanced. Along this line all the material carried by the ice was deposited, and thus formed a ridge of earth called a terminal or peripheral moraine. There is some evidence which indicates that along the northwestern border of the Erie lobe in Dekalb County two of these terminal moraines are piled up against and coalescent with the interlobate moraine. The position of the crest so much nearer the Erie border than the Saginaw border, the greater smoothness of the southeastern slope, and the comparatively small number of lakes upon that slope may thus be accounted for. Two terminal moraines remain distinct. *The Wabash aboit moraine* extends from Hillsdale County, Michigan, along the right bank of the St. Joseph River to the northeastern corner of Huntington County, Indiana, thence along the right bank of the upper Wabash River to Mercer County, Ohio. In Dekalb County it occupies the space between the river and Cedar Creek Valley. *The St. Mary's and St. Joseph moraine* extends from Lenawee County, Michigan, along the left bank of the St. Joseph River to Fort Wayne, Indiana, thence along the right bank of the St. Mary's River to Allen County, Ohio. In Dekalb County it occupies the space between the river and the southeast corner of the county.

The ridges on either side of the St. Joseph are broad but comparatively high and rolling tracts of land. That upon the western side is the more massive and level. It bears upon its surface numerous and extensive swamps, depressions wherein the water is retained by impervious strata of clay. These are being drained by an elaborate system of ditches chiefly into the St. Joseph. Its western slope is quite abrupt, and in Jackson Township cut by deep ravines. Here occurs the only lake east of Cedar Creek, Duncan's Lake in section 31. Its basin is a symmetrical oval, about eighty acres in extent, with bold shores and a border of marsh all around it. One mile northwest, in section 36, is a similar basin of double the area, now occupied by a black ash swamp. Both are drained into the St. Joseph, although the swamp is only a mile from Cedar Creek. Just south of the Dekalb County line the moraine rises to its highest elevation in "Dutch Ridge," Perry Township, Allen County, about 900 feet above the sea. Near the northeast corner of Dekalb County, this moraine is crossed by Fish Creek, which has cut a valley 25 to 40 feet below the general level. That portion of the county which lies upon the interlobate moraine presents surface features distinctly different from those of the terminal moraines. The topography is more strongly morainic, and characterized by high, irregular ridges, abrupt slopes, deep winding valleys and numerous lakes. These characters in great variety and perfection render Fairfield Township the most picturesque portion of the county. In sections 3 and 4 Story Lake occupies a valley now much too large for it, and empties northward into Pigeon River and the St. Joseph of Lake Michigan. Indian Lake (section 29), Cedar Lake (section 30, Smithfield), and several smaller bodies of water form the sources of Cedar Creek which flows down the slope to the southeast until it strikes the western border of the Wabash, Aboit moraine, and is turned to the southwest. These lakes, originally shallow, are being rapidly encroached upon by the growth of aquatic vegetation. The open water is surrounded by a wide border of quaking bog, so that a solid shore for launching or landing can hardly be found anywhere. The water swarms with vegetable and animal life, and furnishes an almost inexhaustible store of material for the naturalist. The artist, too, would find here many forms fit for his study and use. He would have only to copy and combine the shapes and tints of pickerel weed, spatter-dock, arrow-head and pond lily to form designs at once natural, beautiful and unique. The lakes are all approaching the verge of extinction, and in a few years or generations will become swamps, or, by artificial drainage, fertile farms. Some of the lakes of this region have met a different fate. Instead of being gradually filled with muck from the bottom, they have been buried alive by a growth of vegetation which has spread over the surface of the water. The L., S. & M. S. Railroad attempted to cross such a one three miles west of Waterloo, but the track fell through into water 40 to 60 feet deep. The "sink hole" was finally bridged with timber and old ties. The final stage of a lake, just before extinction, is often a tamarack swamp, of which there are many examples in the county. The largest, just west of Garrett, occupies more than a square mile, and still conceals within a small remnant of open water.

During the period of the melting glacier large quantities of water poured over the country in channels now much too large for the insignificant streams which occupy them. The soil was washed over, sorted out and rearranged, and the general unevenness of the surface was greatly reduced. The smoothing process is still going on, and many prominent features of topography have been obliterated or buried. At that time the St. Joseph River continued its southwest course into the Wabash through a channel now occupied by the Little River prairie from Fort Wayne to Huntington. The Maumee River had no existence, its present basin being partly occupied by the retreating ice, and partly by a lake which emptied into the St. Joseph, at Fort Wayne. There is abundant evidence to show that the latter river was originally much larger than at present, and flowed at a level about 25 feet above its present bed. Its valley in Indiana is seldom less than half a mile wide. The river is bordered by plains and terraces of fine sand, whose limits are sometimes indefinite, but usually marked by a distinct bluff. In sections 6 and 7, Newville, the east bank is bordered by a wide terrace 25 feet high for a distance of three miles. Where crossed by the Hicksville road it is broken by benches of three or four feet into three terraces. In sections 32, 29 and 28, Stafford, a series of low sand dunes rest upon this terrace and extend about two miles, the northern half along the right bank, and the southern half along the left bank, but at a distance of a quarter of a mile from the river. Opposite Spencerville, section 33, Concord, the bluff is 35 feet high, broken by a terrace 20 feet above low water, which extends up the river to a hummocky ridge of sand half a mile long, and 20 to 30 feet high. These peculiar features of terrace and dune are continued along the river in Allen County. The ridges exactly resemble kames, but their position indicates that they were formed by the action of water rather than by ice. Yet that the river ever stood high enough to flow over them seems a rather violent supposition.

Throughout the innumerable variations of soil in Dekalb County, one law prevails: upon the elevations the soil is clay, in the valleys sand and gravel. The railroad cut at Corunna shows 18 feet of clay underlaid by coarse sand, and this is a typical specimen. Continued observation has deepened the impression that the whole region was originally covered by a sheet of clay, which subsequent erosion has cut through and removed, except upon the higher points. The source and manner of deposit of this upper member of the drift is still an open question. That it was the surface load of the glacier and deposited by the final general melting of the mass, that it is the sediment from the waters of a post-glacial lake, and that it was dropped by floating icebergs, are each possible but hardly satisfactory theories. During the post-glacial subsidence of the waters and the rearrangement of materials, some remarkable results were accomplished. On the farm of A. Stapleton section 31, Stafford, in a basin of about ten acres extent, under three or four feet of quaking muck, has been found a bed of calcareous clay of unusual character. Its color is a very delicate light gray, which darkens a little on exposure to the air. When wet it is so smooth and unctuous as to have led to the belief that it contains oil. When dry it forms a compact mass which can be polished until the surface resembles glass or marble. The dry powder is as fine and soft as flour without a particle of grit. It is alkoline in reaction and acts as a very efficient cleansing, scouring and polishing agent for all surfaces. On account of its tenacity it can be moulded into the most delicate ornamental designs, and specimens of pottery made from it burn extremely hard and of a light terra cotta color. The following analysis shows its chemical composition:

Calcium carbonate	15.00	per cent.
Magnesium carbonate	1.84	" "
Ferric oxide	4.52	" "
Silica	37.32	" "
Alumina	29.85	" "
Combined water	11.47	" "

Its physical characters are more remarkable than its chemical. It is genuine "rock-flour," which could be produced in no other way than by

* * * the slow and ponderous creep
Of ice a thousand fathoms deep.

By what delicate adjustment of currents was this flour sorted out from all admixture of coarser particles, and finally deposited by slow settling from still water until the basin of the little lake was filled with it to a depth of more than twenty feet. It is a product of glacial action as peculiar and characteristic as striated stones, and it ought to be distinguished by the name of *glacierite*.

The following section of the drift in the boring for gas at Butler is instructive:

"Hard-pan" (generally clay)	15	feet.
Gravel and coarse sand	275	"
Red quick sand	40	"
Clay (glacierite)	45	"
Cobble stones and bowlders	3	"
	378	"

The same stratum of bowlders at the bottom of the drift was struck in the boring at Garrett. Borings for gas have been made at four different localities in the county, sections of which are shown in the following table:

	Auburn.	*Garrett.*	*Butler.*	*Waterloo.*
Surface above sea level	872	892	867	887
Drift	280	378	378	365
Black shale	120	. .	108	. .
Limestone	963	1,050	1,064	. .
Shale	568	. .	500	. .
Trenton Limestone at . . .	1,937	1,912	2,050	. .
Total depth	1,964	2,220	2,139	. .

Boring No. 1 at Auburn yields gas estimated at 450,000 cubic feet per day. No. 2 was shot and filled with salt water; it nevertheless yields gas, the water being "blown off" once a day. A third boring is in progress. In the Butler well gas was obtained, but after being shot with 120 quarts of nitro-glycerine the well was filled up 200 feet and the flow stopped. The Waterloo boring yields a quantity of gas nearly equal to that at Auburn. The Garrett boring yielded no gas.

The drift of Dekalb county has furnished some interesting and unusual specimens. A mass of pure galena weighing ten pounds was found near Corunna. Near Fairfield Center a large bowlder of mica schist was full of crystals of colophonite, some as large as a hen's egg. A small nugget of pure copper found in Wilmington Township may have been an aboriginal importation free of duty, but the occurrence of the galena remains a mystery. That savage races often regard black stones as sacred is well known, and the conjecture is not unreasonable that the brilliant black mass of lead ore may have been brought to Indiana and treated as a god. Mastodon remains have been found in five different localities in the county, one in section 27, Smithfield, being remarkable because the bones, excellently preserved, were found not in a swamp but under four feet of blue clay.

Hon. R. Wesley McBride, of Waterloo, who has given much attention to the geology and archæology of his county, reports mounds and prehistoric remains as being very abundant. Out of mounds and fortifications examined by him in eleven different localities he has obtained a large collection of pottery, stone implements and human bones. From one mound near Waterloo the skeletons of at least twenty-five persons were exhumed. They had been thrown in promiscuously and covered with twelve or fifteen feet of charcoal.

REPORT UPON THE GEOLOGY OF ALLEN COUNTY.

BY CHARLES R. DRYER, M. D.

The county of Allen was organized in 1823, out of territory then included in Randolph and Delaware counties. It is bounded on the south by the counties of Adams and Wells, on the west by Huntington and Whitley, on the north by Noble and Dekalb, and on the east by the State of Ohio. It is 24 miles wide from north to south, and its length from east to west varies from 26 to 28 miles. It includes 16 whole townships and 4 fractional, being a total area of about 664 square miles. For convenience of reference the civil names of the congressional townships are given in the following table:

	R. 11.	*R. 12.*	*R. 13.*	*R. 14.*	*R. 15.*
Tp. 32.	Eel River.	Perry.	Cedar Creek.	Springfield.	Scipio.
Tp. 31.	Lake.	Washingt'n	St. Joseph.	Milan.	Maumee.
Tp. 30.	Aboit.	Wayne.	Adams.	Jefferson.	Jackson.
Tp. 29.	Lafayette.	Pleasant.	Marion.	Madison.	Monroe.

Allen County is crossed by the parallel of 41° north latitude, the meridian of 85° west longitude, and the annual isothermal of 52° F. Its annual rainfall is about 35 inches, and its average elevation not far from 800 feet above sea level.

The city of Fort Wayne (population 30,000), the county seat, and the third city in the State, is situated three miles west of the center of the county at the junction of its three principal rivers, the St. Joseph, St. Mary's and Maumee. Its site is at the beginning of the portage from the Maumee to the Wabash rivers, and its occupation as a French trading post probably dates back to 1680.

The county is crossed east and west by the Wabash, St. Louis & Pacific, the Pittsburgh, Ft. Wayne & Chicago, and the New York, Chicago & St. Louis railroads; north and south by the Grand Rapids & Indiana, and Cincinnati, Richmond & Ft. Wayne, the Ft. Wayne, Cincinnati & Louisville, and the Ft. Wayne branch of the Lake Shore & Michigan Southern. The population of the county is nearly 60,000.

Physically, Allen County is a part of that shallow trough which continues the basin of Lake Erie southwestward across Ohio and Indiana nearly to the borders of Illinois, and which I shall call the Wabash-Erie region. The county lies exactly midway of this trough, where a curved, transverse ridge forms a divide which turns a portion of the water northeastward through the Maumee to Lake Erie and the remainder southwestward through the Wabash to the Ohio. This region exhibits a continuity and unity of structure which indicate that the whole has been shaped by the action of one agent. Many features of its topography and drainage are anomalous, unique and explainable only by reference to a single cause.

Along the present axis of the trough extends one uninterrupted river channel, occupied, however, by different streams; from Lake Erie to Ft. Wayne by the Maumee, thence for about twenty miles by a marsh known as the Little River Prairie, thence by the Little Wabash River to its junction with the great Wabash below Huntington, and thence by the latter river. Down the sides of the trough ten streams of considerable size flow toward the central axis, arranged opposite each other in pairs, the Auglaize and the Tiffin, the St. Marys and the St. Josephs, the Upper Wabash* and the Aboit, the Salamonie and the Eel, the Mississinewa and the Tippecanoe. Those upon the southern side occur at regular intervals and flow in symmetrical curves parallel with the southwest shore of Lake Erie. The drainage system as a whole is almost sagittate in form, resembling the shape of an arrow with a five-barbed head. The general course of the ten tributaries is toward the western end of the trough, and, according to hydrographical precedents, all ought to be tributaries of the Wabash River; yet four are on the eastern side of the divide and turn back upon themselves in a remarkable manner The St. Mary's River, after flowing northward sixty miles, and the St. Joseph, after flowing southwestward eighty miles, unite to form the Maumee, which then turns abruptly to the northeast; so that in a course of ten miles the waters of the St. Joseph suffer a change in direction of more than 160 degrees. The key to this unusual behavior was discovered in 1870 by Mr. G. K. Gilbert, then of the geological survey of Ohio. He found closely following the eastern banks of these rivers a ridge which he conceived to be "the superficial representation of a terminal glacial moraine."† About the same time Professor N. H. Winchell was studying these and other ridges in northwestern Ohio, which he described in detail in a paper read at the meeting of the American Association for the Advancement of Science at Dubuque in 1872.‡ He pronounced all the ridges described to be terminal moraines of a local glacier which passed

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*The Wabash above Huntington.

†Geological Survey of Ohio, Geology, Vol. I., p. 540.

‡Proceedings of A. A. A. S. for 1872, p. 152.

up the St. Lawrence valley and was protruded into the *cul-de-sac* of the Maumee. In 1881 Professor T. C. Chamberlain published his classic report upon the Terminal Moraine of the Second Glacial Period,* from which it appears that the ice did not stop at Ft. Wayne, but pushed on nearly to the western border of Indiana.

The discovery of the key to the peculiar structure of the Wabash-Erie region is due to the sagacity of Mr. Gilbert. The sequel may show that this key has been applied with too little discrimination; but there is now no reason to doubt that the parallel, crescentiform ridges which determin the course of the principal streams of this region are of glacial origin an morainic character. Allen County is traversed by two such ridges, and further discussion of the subject will be confined to them.

The surface of the county is everywhere covered with a sheet of drift seldom less than 100 feet in thickness. The character and disposition of the drift govern its topography, control its drainage, and determine its agricultural character. A study of the geology of Allen County must be almost exclusively a study of the drift. For convenience of description the county may be divided into six natural divisions.

1. The Maumee Lake Region.
2. The St. Mary's and St. Joseph Moraine.
3. The St. Mary's Basin.
4. The St. Joseph Valley.
5. The Wabash-Aboit Moraine.
6. The Aboit and Eel River Region.

THE MAUMEE LAKE REGION.

Once covered by the waters of a glacial lake, forms a triangle with a base of 18 miles on the east line of the county, and its apex in section 3 Adams Township. It occupies the townships of Jackson and Maumee, the greater part of Scipio and Milan, one-half of Jefferson and portions of Springfield, St. Joseph and Adams, and has an area of about 120 square miles, or nearly one-fifth of the county. This lake emptied westward into the Wabash channel, and its eastern shores were probably formed by the ice-foot or wall of the retreating glacier. The Blanchard ridge† of Winchell marks the next halting place of the ice-foot, and was probably for a time the eastern boundary of the lake. During that period it was an intermorainic lake, and had an area of 800 or 1,000 square miles, and a maximum depth near Emerald, Ohio, of perhaps 60 feet.‡

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*U. S. Geol. Surv., 3d Annual Report, p. 291.

†This ridge is a terminal moraine approximately parallel with the St. Mary's and St. Joseph moraine. It extends from Adrian, Mich., to the Maumee, below Defiance, Ohio, thence southeastward to the Putnam County line, thence eastward through Leipsic and Fostoria to Tiffin.

T. P. Roberts' letter in the Toledo Blade, February 22, 1876.

The surface of this region is remarkably uniform,* being in some places an absolute level and occupied by extensive marshes, such as "great bear swamp," in Jackson Township. The streams are crooked and sluggish, and proper drainage, always difficult, is often impossible. It exhibits all the characters of the "Black Swamp" of Ohio, of which it forms a part The surface soil is chiefly a compact bowlder clay, overlaid in some places by laminated clays, with here and there a patch, streak or ridge of sand or gravel. The clay is commonly yellow to the depth to which aerated water has penetrated, below that blue. The boring of wells reveals the presence of layers or pockets of sand and gravel, which form the water-bearing strata.

Along the northwestern borders of this region "fountain wells" are very common. Near the line between Springfield and Milan and Maumee townships, there are as many as twenty within a distance of three miles. Flowing water is usually struck at depths between 35 and 45 feet, and a copious stream rises to the surface, or a few feet above. The following section of Rupert's well (section 1, Milan), is typical:

Yellow clay	7	feet.
Blue clay with gravel	20	"
"Putty clay"	5	"
Quicksand	1	"
Water bearing gravel, with coal	3	"

The "coal" often comes up in considerable quantities. It consists of black water-worn fragments, never larger than a cherry, which chemical analysis shows to contain—

Volatile matter	14.17
Coke	64.12
Ash	21.71
	100.00

These wells are all south of the Hicksville ridge and the water probably comes from the higher ground of the St. Joseph ridge.

Through this region, in a course almost parallel with its northern border and not more than four miles from it, the Maumee River flows in an exceedingly tortuous channel 25 to 40 feet deep, and with a fall of not more than one foot to the mile. At Bull Rapids (Maumee township) the channel is 360 feet wide and the banks 30 feet high. In section 22, Milan, the banks show 25 feet of gravelly clay, underlaid by 5 feet of very coarse gravel and bowlders, most of the stones being well rounded, but as many as one in twenty being flat and beautifully striated on one or both sides.

*Wabash & Erie Canal at State line	750	feet	A. T.
N. Y. C. & St L. R. R. "	761	"	"
New Haven, Allen County, Ind.	762	"	"

The Maumee has no flood plain, terraces, benches, or bluffs. Its numerous northern tributaries rise within two or three miles of the St. Joseph River, and flow directly down the slope of the trough It has almost no tributaries from the south, nearly all the streams within 20 miles of it flowing parallel with it. Platter Creek rises in Milan Township, within two miles of the Maumee, and flows northeast about 25 miles to the Auglaize. The numerous branches of Flat Rock Creek, which drain the southeast corner of the county, unite to form a sluggish and serpentine stream, which flows parallel with the Maumee at a distance of ten miles, and also empties into the Auglaize.

The Maumee Lake region is bounded upon the southwest and northwest by the Van Wert ridge of Winchell. It branches from the Blanchard ridge at Findlay, O., passes through Benton, Webster, Pendleton, Delphos and Van Wert, across the southwest corner of Paulding county, and enters Indiana in Section 2, Monroe township, Allen county. Thence it pursues a somewhat irregular course presently to be described, to New Haven. The portion north of the Maumee called the Hicksville ridge, begins in Section 3, Adams township, extends in an almost straight line to the northeast corner of Allen county, and continues thence through Hicksville, Williams Center, Bryan, West Unity and Fayette, Ohio, to and beyond Adrian, Michigan, where it probably again joins the Blanchard ridge. The arrow head-shaped space enclosed by these ridges, its point being at New Haven, the extremities of its barbs at Adrian and Findlay, and the bottom of its notch at Defiance is the area once covered by the waters of the Maumee Lake.

The Van Wert and Hicksville ridge is regarded by Prof. Winchell as a terminal moraine, but by Mr. Gilbert and Prof. Newberry* as a lake beach or shore line. After a careful examination of it in Allen county, the evidence in favor of the latter view seems to be decisive. In Van Wert county, Ohio, the ridge breaks up into several members, and enters Allen county in at least four parts, all in Monroe township. The most southerly branch crosses the State line on the middle line of Section 14, and can be traced into the northeast quarter of Section 16. It is a sand and gravel ridge four or five feet high and three rods wide, trending E. S. E. by W. N. W. A second similar and parallelridge crosses the State line one-fourth of a mile north of south line of Section 11, and ends a few rods to the west.

A third ridge crosses one-fourth of a mile north of the second and can be traced to the northwest corner of Section 10. The main branch enters Allen county a few rods north of south line of Section 2. It is a ridge of fine gravel and coarse sand averaging twenty rods in width and ten feet in height, but is quite variable. It extends northwest to the center

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*Geological survey of Ohio, Geology vol. II, p. 57.

of the northwest quarter of Section 3, thence west one mile, thence northwest to center of southeast quarter Section 32, Jackson township, where it ends abruptly. Thence to the center of Section 36, Jefferson township, where the ridge again appears, is a gap of more than two miles, to pass through which the upper branches of Flat Rock Creek converge from the west, south and southwest. In Sections 36 and 25, Jefferson, the ridge trends a little west of north, and is very strong, its dimensions being fully twice the average given above. In Section 23 it is much less prominent, and in the northeast quarter curves sharply to the west. At Besançon, northwest quarter of Section 22, it becomes a quarter of a mile wide and divides into two branches. The north branch fades out near the center of Section 16, and the south branch runs west to the southwest corner. Thus far the ridge is quite symmetrical, sloping equally on both sides; but on entering the southeast corner of Section 17 it becomes a bench or terrace slightly elevated above the general level on the south, but sloping northward forty rods to a level twenty to thirty five feet below. It maintains this character to the southwest corner of Section 7, where it becomes a ridge of fine sand twenty feet above the level on the south and thirty to forty feet above the plain on the north. It traverses the south half of Section 12, Adams township, passing a little south of New Haven, and near the center of Section 11, becomes broader and bends back southward a half mile into Section 14, where it terminates. The west end and southward extension is composed of rather coarse gravel. Six Mile Creek has cut off the northwest angle and it has been excavated for road building. The section at the gravel pit shows strata of coarse sand and gravel in somewhat confused anticlinal stratification, having a total thickness of twenty-three feet, and underlaid by clay. The summit of the ridge is thirty-five feet above the creek. At a point on the very crest of the ridge one mile east of its western end, E. W. Greene had just bored a well seventy feet deep from which the water was flowing in a half inch stream, although the level seemed to be higher than that of any land visible around it. The boring was through sand twenty feet and gravelly clay fifty feet to water bearing quicksand.

North of the Maumee the Van Wert ridge is continued by the Hicksville ridge, which extends eastward from Ft. Wayne along the north line of Adams township to the center of the northwest quarter of section 3, where it makes a sharp bend of 110° toward the northeast. At northwest corner of section 35, St. Joseph Township, it becomes triple, the middle branch being in a direct line with the previous and subsequent course. The inner branch, next the lake, curves away to the distance of quarter of a mile, and rejoins the middle one a little east of the southwest corner of section 24. The outer branch is a bench parallel with the middle one and 40 rods from it. The triple character is maintained for about two miles, and without detriment to the mass of either branch. Thus far the ridge is a rounded, symmetrical pile of sand and gravel of an average height of 25 feet above the lake bottom on the southeast, and with a slope of about half that fall to the northwest. Beyond the center of section 24 the ridge is broad, irregular and more difficult to define, the descent toward the northwest being slight or wanting. There is everywhere, however, a strong contrast between the flat bottom land on one side and the higher, rolling country on the other. It passes with slight deviation to Maysville, where it again assumes a regular and symmetrical character, and continues thence to the northeast corner of the county.

The true nature of the Van Wert ridge will be better understood after a consideration of other similar ridges which lie between it and the Maumee River The most prominent of these is known as "Irish Ridge." It begins with a broad mass of gravel occupying the center of section 9, Jefferson Township. It was originally half a mile long, a quarter of a mile broad, and 10 or 12 feet thick, of fine gravel in perfect anticlinal stratification. From the gravel bed a ridge 15 feet high and five or six rods wide extends a little south of east across sections 10, 11 and 14, and into 13. Its eastern half is broader and not so well defined, and runs out into a mere streak of yellow sand. Its length is three miles and its direction parallel with the Van Wert ridge, from which it is distant a mile and a half.

Another called "Briar Ridge," is reported as extending northwest and southeast across section 15, Jackson Township, but I have not examined it. Small sand ridges parallel with the Hicksville ridge were noticed in sections 6 and 7, Milan Township, and probably others occur in the Lake Region. The following altitudes on the Van Wert Ridge have been obtained from various sources, chiefly railroad levels:

Gorham Township, Fulton County, Ohio	798 feet.
West Unity, Williams County, Ohio	803 "
Pulaski, Williams County, Ohio	773 "
Bryan, Williams County, Ohio	771 "
North of New Haven, Allen County, Ind	775 "
West end of Irish Ridge, Allen County, Ind	779 "
South of New Haven, Allen County, Ind	802 "
Van Wert, Ohio	786 "
Delphos, Ohio	784 "
Average height about	800 "

The character of the Van Wert Ridge may be summed up as follows:

1. It is composed of sand and gravel in more or less regular anticlinal stratification.

2. It is superficial, a deposit not over 20 feet deep (or high) superimposed upon the fundamental clay of the country.

3. It is narrow, sinuous, and frequently broken up into several members, each member being symmetrical and often equal in mass to the main ridge.

4. It offers little obstruction to the course of streams, being broken by frequent gaps for their passage.

5. Its crest shows a remarkable uniformity of level.

These characters mark it unmistakably as being not a glacial moraine, but a lake beach. Irish ridge is evidently an off-shore bar, and may have been the cause of the somewhat weak and confused character of the main ridge immediately south of it. The contrast between the simplicity and directness of the Hicksville ridge and the irregular complexity of the Van Wert ridge is readily accounted for. On the north the waters of the Maumee lake beat against the straight and bold escarpment of the inner margin of the St. Joseph ridges, while on the south the inner slope of the St. Mary's ridge, east of the centre of Jefferson Township is so gentle as to be imperceptible. The water crept up this slope in wide shallows and a change of level of a few feet would move the shore line as many miles. West of the center of Jefferson Township the inner margin of the St. Mary's ridge is high and bold, the main Van Wert ridge is coincident with it, and this fact explains all its anomalies.

Connected with the Maumee lake are two ancient drainage channels, the Six-Mile Creek channel and the Wabash-Erie channel. The former is a channel through which the St. Mary's River once emptied into the lake. It can be easily traced from the great bend of the St. Mary's River at the north line of section 7, Marion Township, to the Maumee at New Haven. It follows the valley of Merriam's Creek for half a mile, then the course of the Trier ditch northward through sections 5, Marion, and 32 and 29, Adams, thence along Six-Mile Creek through sections 20, 21, 15, and 11, to New Haven. The summit is in section 32, and is 20 feet above low water at New Haven, and not more than 10 feet above low water in the St. Mary's, so that frequently the St. Mary's water overflows the summit. The width of the channel is uniformly a quarter of a mile until it reaches section 15, where it begins to widen, and on the line between sections 10 and 15 it is a mile and a half wide, being bordered on the east by the high western face of the recurred end of the Van Wert ridge, and on the west by a similar ridge hereafter to be described. The banks of the channel have an average height of 15 feet, but the levels of the P., Ft. W. & C. R. R. show that the bottom of it is 60 feet below the summit on the west, and 40 feet below that on the east. It cuts completely through the St. Mary's ridge and may have afforded passage for ice or water either way. That a considerable stream once traversed it toward the north is shown by the terrace or delta of sand at the New Haven end.

THE NEW HAVEN DELTA

Is a deposit of sand which might be regarded as a western extension of Irish Ridge. Its eastern end is half a mile wide at middle of south half of section 5, Jefferson, whence it extends westward and occupies nearly all the space between the margin of the St. Mary's Ridge and the Maumee. The Maumee touches it in section 1, Adams, and again in section 3, and it continues as a narrow terrace nearly to Ft. Wayne. It is exactly opposite the Six Mile Creek gap, and was undoubtedly formed from materials washed through that gap. Its average elevation above the lake bottom is 10 feet, frequently rising along its margin to twice that height.

THE WABASH-ERIE CHANNEL

Is a part of the axial channel of the Wabash-Erie trough, and once carried the waters of the Maumee Lake to the Wabash River. It begins in section 3, Adams, where between the before mentioned angle of the Hicksville ridge and the margin of the New Haven delta it has a width of only half a mile; but to the margin of the St. Mary's ridge is a mile and a half. Thence westward four miles to Ft. Wayne, the channel cuts through the St. Mary's and St. Joseph moraine, and narrows to a width of five-eighths of a mile. This portion is bordered on the north by a prolongation of the Hicksville ridge, and on the south by the cut edge of the moraine which rises in the city to a bluff 50 feet high. At the western border of the moraine the channel turns to the southwest in a line which is a direct continuation of the valley of the St. Joseph River. For the next eight miles it is one mile wide, and has for its northern bank a line of bluffs 60 feet high, formed by the border of the Wabash-Aboit moraine. The Wabash & Erie Canal follows closely the foot of these bluffs. It is bounded on the south by a system of kames hereafter to be described. In section 35, Aboit Township, it is joined from the east by a former channel of the St. Mary's River, and its width is increased to a mile and a half. It then turns westward along the south line of that township and cuts through the Wabash-Aboit moraine. Here it again narrows to one mile, and its banks attain their highest elevation, the bluffs on either side at the mouth of the Aboit River being more than 100 feet above the present bottom of the channel. On entering the northeast corner of Huntington County it curves southward along the western face of the Wabash ridge, to the south line of Jackson Township, where it turns again westward. Just above Huntington it expands to a breadth of more than two miles, narrows again in passing the city, and enters the present Wabash Valley two miles below.

The Wabash-Erie channel has a total length of 30 miles, two-thirds of which is occupied by a marshy prairie and traversed by the insignificant

Little Wabash, or Little River. The peat bed is about four feet thick and underlaid by blue clay. At Lewises' ford, three miles above Huntington, the peat and clay end, and below there the bottom is of Niagara limestone. This channel was undoubtedly the avenue of escape for the waters of the Maumee Lake and the St. Joseph and St. Mary's rivers, and its level is about 150 lower than that of any other pass crossing the divide out of the Erie basin. The present level of its bottom rises from 737 feet at the mouth of the St. Joseph to 756 feet at the summit four miles west, then falls to 744 feet at the margin of the Niagara outcrop, and to 699 feet at its junction with the Wabash. The silt at the summit is about 40 feet deep, and if it were removed the summit of the rock bottom would be the limestone ledge at Lewises' ford. The water in this channel may have had originally a depth of 70 feet, and the river which post-glacial man may have seen there was comparable with the Niagara itself.

THE ST. MARY'S AND ST. JOSEPH MORAINE.

This is the longest and most important ridge in the Wabash-Erie region, and has been described by both Winchell and Gilbert; but concerning its course east of Lima, Ohio, they do not agree. From Lima it runs west and northwest along the right bank of the St. Mary's River to Ft. Wayne, thence northeast along the left bank of the St. Joseph to Hudson, Michigan. Winchell describes it as being "like a dead wave on the surface of the ocean, hardly perceptible to the eye on account of its smoothness, but revealed by its effect upon everything that encounters it." This effect is most striking upon the course of the St. Mary's River. Its headwaters in Auglaize and Mercer counties, Ohio, flow directly northward toward the Maumee until they encounter the ridge and by it are deflected to the west. The crest of the ridge can be easily traced upon the map, since it forms the watershed between the St. Mary's and the Auglaize at a distance of about 4 miles from the former and 30 miles from the latter. In Allen County the Wayne trace, or old Piqua road follows the crest. Its inner slope is gentle, its outer more abrupt, the fall from the summit to the St. Mary's at south line of Allen County being not less than 80 feet. In the southern townships the ridge is perceptible only upon the map, that is by its influence on the course of streams; but in Adams and Wayne townships it becomes rolling, with bluffy margins, kames and other notable features of a terminal moraine. The inner margin has already been described from the center of Jefferson township to the Six Mile Creek gap. On the west side of that gap it begins near west line of section 15, Adams, and continues as a bold bluff 40–50 feet high across sections 9, 8 and 6 and through the city of Ft. Wayne to the point where the Wabash and Erie Canal (now N. Y., C.

and St. L. R. R.) crosses the St. Mary's. The peculiar features of the ridge south of that point will be described in another connection. The summit in section 7, Adams, is 76 feet above the mouth of the St. Mary's. The ridge is composed chiefly of bowlder clay with a border of sand and gravel around its northern end.

The St. Joseph Ridge is more simple in structure and direct in course than its southern complement. It extends from Ft. Wayne along the left bank of the St. Joseph River beyond the borders of Michigan. It fills the space between the river and the Hicksville Ridge. In Indiana its breadth is four miles, but it widens toward the north. It is a slightly rolling strip of country, which occupies the greater part of the Townships of St. Joseph and Springfield, and a portion of Cedar Creek and Scipio. According to ditch levels the crest is 50 feet above the Maumee Lake bottom in St. Joseph, and 70 feet in Springfield. The following levels show the very uniform longitudinal slope of the ridge from the extremities toward the apex:

Hudson, Lenawee County, Mich	927	feet.
Summit west of Bryan, Williams County, Ohio	873	"
Summit west of Hicksville, Defiance, Ohio	849	"
Wabash-Erie channel, head of Maumee River	737	"
Summit east of Ft. Wayne, Allen County, Ind	813	"
Summit, section 32, Madison, Allen County, Ind	846	"
Two miles south of Spencer, Allen County, Ohio	872	"
Two miles south of Lima, Allen County, Ohio	895	"
One mile north of Hog Creek Marsh, Hardin County, Ohio	914	"

If there was ever any reason to doubt the morainic character of the St. Mary's and St. Joseph Ridge, there can be none now, since its connection with the great morainic system of North America is evident. The shape and position of the ridge, regardless of its structure, show it to be a terminal or frontal moraine of the Huron-Erie ice lobe, and to mark the position where the ice-foot halted for a time in its retreat toward the Canadian highlands. It is simply a place where the bowlder clay is 50–75 feet thicker than usual, and there is no evidence to support the conjecture of Gilbert that it is the surface manifestation of a buried mass of material different from the common drift of the region.

THE ST. MARY'S BASIN.

The St. Mary's River rises in Auglaize County, Ohio, and follows the outer face of the St. Mary's moraine for about 60 miles. Near the center of Wayne Township, Allen County, Ind., it cuts through the apex of the moraine, emerges from it in section 10, and follows thence the southeast bank of the Wabash-Erie channel to its junction with the St. Joseph. It is a sluggish, muddy stream, without bluffs or flood plain, the highest water seldom being more than sufficient to fill its channel. Its minimum flow is estimated to be from 1,500 to 2,000 cubic feet per minute.* Its basin lies almost exclusively upon its left bank, and consists in Indiana of a strip of flat country 10 or 12 miles wide, lying between the St. Mary's and the Wabash ridges. In its lower course the river has been tossed about from one channel to another repeatedly. The Six-Mile Creek channel is probably the oldest and has already been described. A second abandoned channel leaves the river at the southeast corner of section 22, Wayne township, turns southwest across sections 28, 29, 30 and 31, Wayne, and 36 and 35, Aboit, where it joins the Wabash-Erie channel. It now forms an arm of the prairie 6 miles long, half a mile wide, at a level 15 feet above the present bottom of the river. A third and later channel at a lower level leaves the river one mile below the second, and passes directly westward through sections 21 and 20, to the Wabash-Erie channel. It is two and a half miles long and a quarter of a mile wide. The greater part of the triangular space between the second St. Mary's channel and the Wabash-Erie channel is occupied by a system of sand ridges, which form a projection from the apex of the St. Mary's moraine, and a continuation of the kames, which are a part of that moraine. For convenience of description I shall call them all kames, leaving the question of their true nature for future discussion. On the east the system is almost continuous with the Van Wert ridge.

Kame No. 1 forms the western wall of the Six-Mile Creek gap in section 15, Adams. It is 20 rods wide, 20 feet high, and half a mile long, composed of gravel in anticlinal stratification. It is a reduced counterpart of the recurred western end of the Van Wert ridge.

Kame No. 2 lies upon the summit of the St. Mary's ridge, in the eastern part of the city of Ft. Wayne. It is a broad sand ridge extending from the east line of section 7, Adams, westward a mile and a quarter. It has been leveled for the new freight yards of the Pennsylvania Co., but west of the railroad it rises into a conical hill 30 feet high.

Kame No. 3, very symmetrical and quarter of a mile long, lies north of and parallel with No. 2, just east of the center of Section 7.

Kame No. 4 begins near the crossing of the Wabash & Erie Canal (now the N. Y. C. & St. L. Railroad), over the St. Mary's River (west end of Berry street, Ft. Wayne), and extends thence as a massive ridge of sand and gravel southward a mile and a half. It has been extensively excavated for gravel by the P., Ft. W. & C. R. R. Co., and is cut through along the Wabash R. R. by the valley of Shawnee run. An eastward branch crosses the Bluffton road (Broadway) just south of Creighton avenue. It fades out in the east half of section 15, Wayne, between the St. Mary's River and the Bluffton road.

*Report of Maj. John M. Wilson, Engineer Corps of U. S. army to Secretary of War, 1880, p. 60.

Kame No. 5 lies on the west side of the river in the west half of section 15, upon the Allen County Poor Farm. It is an irregular, curved and branched ridge of sand extending southward one mile. Where the river abuts against it the bank is 30 feet high.

The remaining kames are of fine, light yellow sand, without admixture of gravel or bowlders, and wholly unstratified.

Kame No. 6 lies west of No. 5, in the north halves of sections 21 and 20. It is very irregular and built upon three parallel axes, but is not complete on either. Two branches extend north into the southeast quarter of section 16, and in the northwest quarter of section 21 it is broken up into conical hills. At the west end it is broad and slopes gently into the Wabash-Erie channel, above which its highest points are 30 feet.

Kame No. 7 begins in a broad mass occupying nearly the whole of the southwest quarter of section 22, and sends two branches westward 40 to 50 rods apart. The south branch extends along the south line of section 21, and disappears at its west line. It is quite regular and 15 feet high. The north branch is low, broad and irregular, until at a point opposite the west end of the southern branch it suddenly rises to 30 feet, and is thence very strong to the middle line of section 20, where it has a double end like a thigh bone.

Kame No. 8 has two branches which separate at the center of the northwest quarter of section 29, and diverge eastward to the east line of the section.

Kame No. 9, three-quarters of a mile long, lies a little north of the center line of sections 29 and 30.

To this system belong several small islands in the Wabash-Erie channel. The Wabash R. R. crosses one in the northwest corner of the southwest quarter of Section 20, and another, Midway Island, a half mile long, in the west halves of Sections 19 and 30. The largest, known as Fox Island, in Sections 25 and 26, Aboit, is more than a mile long and a half mile wide.

Kame No. 10, on Fox Island, is the last and most remarkable one of the system. A beautifully symmetrical ridge, lithe and graceful as a serpent, sweeps in a gentle curve like the Italic letter *S*, or like the human clavicle, westward through the south half of Section 25, three-fourths of a mile long, twenty to twenty-five feet high, and as steep as sand can be piled. Near the west end it sends two parallel branches southeastward. Further west in Section 26, is a straight ridge parallel with these branches, nearly as long as the main ridge, and extending into the southern peninsula of the island. Between the two is an oval, land-locked bay. North of the east end of the main ridge lies a broader and more massive ridge one-fourth of a mile long. The two touch at their eastern extremities but diverge westward. These ridges form the skeleton of the island, the shore lines being filled out in general conformity to them. Fox Island is covered with a light growth of oak, and with the water restored to its bays, would form one of the most charming and unique parks in the world. It is now accessible only to the pedestrian.

The system of ridges just described presents considerable variety of structure and a remarkable gradation between the extreme forms. The Van Wert ridge is plainly a beach deposit, but its western end is 35 feet high, very steep, and bent back southward. All its features are repeated in Kame No. 1, and an examination on the spot, or even an inspection of the map, gives a strong impression that something more unyielding than water must have passed southward through the Six-Mile Creek gap. Kames 2 and 3 are not upon the margin, but upon the summit of the moraine. Nos. 4 and 5 again are marginal, also curved, branched and transverse to the general direction of ice motion. The others are parallel to that direction. No. 6 is broken up like a typical kame, while No. 10 is, in shape and direction, a typical osar. The various forms run into each other so completely that it is impossible to make any but arbitrary distinctions. The series from No. 5 to No. 10 is embraced between and threaded by present and former channels of the St. Mary's River, and the whole region bears the relation of a delta to that river. The river may have furnished the material but it could never have put it into its present shape. The popular notion that these ridges were blown up by the wind is obviously untenable. That they were in some way produced by sub-glacial streams, or in dry tunnels under the ice, seems most probable. The materials may have fallen in from the top as observed by Professor Wright in the Muir Glacier of Alaska,* or it may have been squeezed up from below like the "creeps" in coal mines. The problem of their origin is a puzzling one, and I may be permitted to add my conjecture. The sight of two road scrapers running side by side, and a few feet apart, suggested a possible explanation. Suppose a fissure or tunnel in the glacial mass a few rods wide at the bottom, the motion of the ice would not be exactly parallel and uniform upon both sides of it, and partly by the enormous pressure, and partly by the differential motion, the material of the ground moraine would be squeezed, scraped and plowed up into a steep, symmetrical, continuous and unstratified ridge like the Fox Island kame.

THE ST. JOSEPH VALLEY.

The St. Joseph River rises in Hillsdale County, Michigan, and after flowing in a very direct course southwestward 75 miles joins the St. Mary's at Ft. Wayne, and its waters turn back upon themselves through the Maumee channel. Originally it did not do so, but continued its di-

*American Journal of Science, January, 1887.

rect course through the Wabash-Erie channel to the present Wabash River. The main stream of the Wabash was then a large River for 100 miles above Huntington, to which the present upper Wabash was a small tributary. The basin of the St Joseph lies almost wholly upon its right or western bank, its largest tributaries rising from the Saginaw-Huron interlobate moraine of Chamberlain, in Steuben and Noble counties. Its minimum flow is estimated by Major Wilson to be 4,000 cubic feet per minute. The river is narrowly hemmed in between the St. Joseph moraine on the east and the Wabash-Aboit moraine on the west, the space between averaging less than half a mile wide. Its bed is largely of sand and gravel, and its water much less muddy than that of the St. Mary's. Its valley is bounded by an almost continuous line of bluffs, and numerous terraces reveal its former breadth and higher level. Its waters now rise occasionally to a level less than ten feet below the summit of the divide in the Wabash-Erie channel. Its basin and tributaries will be further described in the next section.

THE WABASH-ABOIT MORAINE.

The Wabash Ridge of Winchell is described as lying along the north side of the Wabash River in Mercer County, Ohio, and extending eastward even as far as Crawford County. It was supposed by him to fade out toward the west, but in fact the Wabash Ridge in Indiana is more strongly defined than the St. Mary's. I have not examined it in Adams County, but in Wells County the levels of the Ft. W., C. & L. R. R show, in the distance of two miles from the summit at Murray Station to the river near Murray Village, a fall of 80 feet. From this point I have traced the outer face of the ridge across sections 8 and 6, Lancaster, 37 and 30 Jefferson, and 25, 24, 13, 14 and 15, Union Township. It forms a line of bluffs often very steep, averaging 50 feet in height, and rising at some points 20 feet higher. From section 16, Union, the bluff fades out into a gentle southwestward slope, across which Langlois Creek cuts transversely. The Wabash River now leaves the ridge at Murray, and flows nearly westward, but it once followed the bluff closely to the Wabash-Erie channel. Two miles below Murray the old channel leaves the present river and runs northward to the south line of section 26, Union, where it joins the channel of Flat Creek, which is amply capacious to carry a river the size of the present Wabash at Murray. From the mouth of Flat Creek (section 2, Union Township, Huntington County), the bank of the Wabash-Erie channel is high and bold, and is formed by the outer force of the Wabash Ridge as far as the northeast corner of Huntington County. The inner margin of the Wabash ridge, in Allen County, is not bold, but can be easily traced from Zanesville northward into section 22, Lafayette, thence trending east of north to the north line of the township, along which the ridge is cut transversely by the Wabash-Erie channel. On the borders of the channel lies a series of ridges and hills, one of which, in section 8, rises at least 125 feet above the level of the channel. The material is everywhere bowlder clay.

The existence of a northern wing to the Wabash ridge seems never to have been noticed previous to the present survey; yet it is the most massive and strongly characterized of all the morainic ridges in the Wabash-Erie region. It extends along the west side of the St. Joseph River from Hillsdale County, Michigan, to the Wabash-Erie channel in Aboit Township; I shall call it the Aboit ridge, and the two together the Wabash-Aboit moraine. The Aboit ridge is bounded on the west in Allen County by the valley of the Aboit River and the marshes about the head waters of the Aboit and Eel Rivers; in Dekalb County by the valley of Cedar Creek; in Steuben County by the valley of Fish Creek, and in Ohio and Michigan by the vallies of other tributaries of the St. Joseph. All these streams behave in a peculiar and remarkable manner. They rise from the Saginaw-Huron interlobate moraine, flow southeast six or eight miles, then, on striking the western face of the Aboit ridge, they turn southwest parallel with it, and after pursuing that course ten to fifteen miles, they turn again at a right angle and cut through the ridge to the St. Joseph River. The interval between the Saginaw-Huron moraine and the Aboit ridge is in Steuben County one mile, in Dekalb County three or four miles. The Aboit ridge in Allen County has a width of from five to six miles and occupies a portion of Aboit and Wayne Townships, nearly the whole of Washington and Perry, and more than half of Cedar Creek. In Dekalb County its width is from six to eight miles. It is crossed by several railroads. Near its southern extremity the levels of the N. Y. C. & St. L. R. R. show a rise from the Wabash-Erie channel to the summit one mile east of the Aboit river of 98 feet, and thence to the Aboit a fall of 50 feet. The P., Ft. W. & C. R. R. rises from the channel to the summit near Hadley, section 36 Lake, 85 feet, thence ne Aboit falls 36 feet. The P. R. and I. R. R. crosses it diagonally, and rises from the channel to the summit north of Wallen 121 feet, thence falls to the marsh near Huntertown 50 feet. The B. & O. R. R. rises from the St. Joseph River at St. Joe, Dekalb County, to the summit one mile east of Auburn Junction, 110 feet, thence falls to Cedar Creek 48 feet. The general elevation of the Aboit ridge above the St. Joseph River is in Indiana about 100 feet, and above the intervale in the west 50 feet, the crest being usually within one mile of the western margin.

It is a broad rolling table land, the chief material of which is gravelly clay; but mounds, patches and ridges of sand and gravel are abundant, especially in Perry township. In northeastern Dekalb County Fish Creek crosses it through a gorge fifty feet deep, flanked by extensive terraces of sand and gravel. In central DeKalb it is flat and swampy, but in the southern part of that county it becomes ragged and broken. In the northern part of Allen county it is crossed by Cedar Creek through a gorge 50 to 100 feet deep, and 800 to 1,000 feet wide. At the bend of the creek, in sections 3, 10 and 11, Perry, the ridge rises to an extraordinary elevation. Here "Dutch ridge," 50 feet higher than the general level to the north and 100 feet above the creek, extends east and west about two miles. The highest point near northwest corner of section 11 is more than 900 feet above sea level and the highest land in Allen county. Duncan's Lake, section 31, Jackson township, DeKalb county, 80 acres in extent, is the largest lake upon the ridge. In sections 7 and 8, Cedar Creek, Viberg's Lake contain 40 acres. In the northeast corner of section 7, Hollopeter's Lake of three acres is 40 feet deep and fed by copious springs at the bottom. On the same farm, but in section 12, Perry, is a little gem which exhibits in miniature the typical character of a morainic lake. It is a perfect oval in outline, about one acre in extent, and is like a crystal mirror set in an elaborate frame. At the edge of the water is a gold and purple rim of *nuphar* and *pontederia;* outside that a strip of pale grayish green shrub, with procumbent branches; then a fringe of higher shrubbery, willow and the magnificent *rhus venenata;* outside of that a straight impenetrable wall of vivid green formed by the tamaracks, *larix Americana*, 40 feet high. The lake was formerly 30 feet deep, but a ditch has lowered the level of water *and shores* six feet. It is surrounded by an extensive peat bog, which on account of the draining away of the water has settled, forest and all, leaving cracks a foot wide running parallel with the shores and encompassing 15 acres. Other morainic lakes differ from this in size, depth, regularity of outline, and continuity and extent of bog; but they all show various stages of progress from a clear, open kettle of water to one entirely filled with peat; from a living lake to an extinct one.

The winding ridges, rounded domes, conical peaks, mounds and hollows which figure so largely in the moraines described by Chamberlain, Cook, Lewis and Wright are not wanting in the Aboit moraine, but are of a subdued type. Characteristic moraine features are present on a small scale. Lindenwood Cemetery, section 4, Wayne, owes its charming beauty to this style of topography, and the same structure prevails over a large part of northern Wayne, Washington, Perry and Aboit townships. At the forks of Spy Run (sections 26 and 27, Washington) there is an extinct lake one mile long and half as wide. Kettleholes occur everywhere, many being shallow, saucer-shaped depressions which have been artificially drained and are now marked only by a few tufts of marsh grass. Upon the bluff near the mouth of the Aboit River (sections 29 and 32, Aboit) there is an interesting group of typical potash kettles, seven within a space of about 30 acres. The largest forms an irregular depression 750 feet long and from 100 to 200 feet wide. The rest are smaller, of oval or circular outline, and about 20 feet deep. Most of the streams which drain the moraine flow at the bottom of gorges of which they now occupy an insignificant portion. Bowlders are common everywhere, but are especially abundant along the outer or western edge of the moraine and in the channels of the streams. They are of all sizes up to ten or twelve feet in diameter. The materials are mostly metamorphic, granite, syenite, gneiss, quartzite, conglomerate, slate and divrite, among which a very compact, fine-grained green diorite is most common. All are much worn, some being rounded and polished like a billiard ball, and many planed and striated. Fragments of Huron shale are occasionally found, and fossiliferous limestone occurs in small pieces. The gravel of the clay is often highly calcareous.

ELEVATIONS ON THE WABASH-ABOIT MORAINE.

Osseo, Hillsdale County, Michigan	1,113 feet.
Summit E, of Auburn, Dekalb County, Indiana	900 "
Dutch Ridge, Allen County, Indiana	923 "
Summit M, of Wallen, Allen County, Indiana	887 "
Hadley Station, Allen County, Indiana	853 "
Summit N. Y. C. & St. L. R. R., Allen County, Indiana	865 "
Wabash-Erie channel mouth of the Aboit, Allen County, Indiana	746 "
Bowman's Sec. 8, Lafayette Township, Allen County, Indiana	873 "
Summit near Murray, Wells County, Indiana	874 "
Summit C. R. & Ft. W. R. R., Adams County, Indiana	865 "
St. Mary's, Auglaize County, Ohio	894 "
Wassakonetta, Auglaize County, Ohio	923 "
Kenton, Hardin County, Ohio	941 "

THE ABOIT AND EEL RIVER REGION.

This region in the northwestern part of the county occupies the townships of Lake and Eel River, and small portions of Aboit and Perry. The lower Aboit River flows through a narrow valley which grows deeper toward the mouth, where it becomes nearly 100 feet in depth. In Lake and Eel River townships the valley broadens to five or six miles, and is occupied by marshy prairie, mostly in wide, tortuous channels with tongues, peninsulas and islands of dry land between. Lakes, living or extinct, are numerous, the largest being Hull's, or Mud Lake, in section 8, Lake, about 150 acres in extent, and White Lake, section 3 Eel River, one-fourth as large. The northwest corner of Lake and northwest half of Eel River lie upon the borders of the Saginaw-Huron inter-lobate moraine, and are quite rolling, the latter being even hilly. The islands and peninsulas upon the western side of the marsh present very curiously and distinctly the morainic topography of mound and hollow upon a miniature scale. The boundaries of marsh and dry land are too irregular for description and can be delineated only upon a map. This variety and irregularity render Eel River Township the most picturesque portion of the county. In sections 13, 14, 23 and 24 the prairie is two miles wide, the north shore being a bluff of 30 or 40 feet in height, from which the view southward across the marsh, sprinkled with wooded islands and projecting points, is worthy of an artist's pencil. The northern portion drains through Willow Creek into Cedar Creek by a channel 20 feet deep and 300 feet wide, the remainder drains into Eel River. The water-shed between the latter and the Aboit is a scarcely perceptible ridge. It is now difficult to determine which way the water does flow or ought to flow, and there is no perceptible reason why Cedar Creek may not once have emptied into Eel River, or the Aboit. Certainly it is impossible to conjecture why its waters should have turned aside from this easy outlet. The present stream would be utterly powerless to excavate the gorge which it occupies through the Aboit ridge. That gorge must be as old as the ridge itself, and must owe its origin to the same conditions and agencies.

GENERAL CONSIDERATIONS.

The peculiar topography of the Wabash-Erie region in Indiana would be strikingly shown by a section along any line radiating southwesterly or northwesterly from Paulding, Ohio. Such a line would run nearly level across the Maumee Lake bottom to the Van Wert and Hicksville Ridge, thence rise 80 or 100 feet in four or five miles to the crest of the St. Mary's and St. Joseph moraine, then fall 50 feet in about one mile, then cross a level interval of from one to ten miles, then show a second gradual rise and more abrupt fall, across the Wabash-Aboit moraine, the second terrace averaging about 60 feet higher than the first. In the southern portion two more similar terraces lie beyond the Wabash Ridge. A portion of one has been described by Winchell under the name of the St. John's Ridge, and is said to extend from the southeast corner of Allen County, Ohio, southwesterly through Auglaize and Mercer Counties to Fort Recovery, where the Wabash River passes through it. D. S. McCaslin has described* its continuation through Jay County, Ind., north of the Salamnine River; also, a ridge known as "Lost Mountain," in the southern part of the same county on the north bank of the Mississinewa River. They are precisely similar in character to the St. Mary's and Wabash Ridges. The levels of the Ft. W., C. & E. R. R. plainly reveal their presence in Wells, Blackford and Delaware Counties, and the courses of the Salamonie and Mississinewa indicate that they extend along those rivers, as the Wabash Ridge does along the Upper Wabash, nearly to their junction with the axial stream. The corresponding

*Twelfth Report Ind. State Geologist, p. 155.

northern wings, if such exist, must be crowded together in northern Huntington and Wabash and in Whitley Counties, or merged with the Saginaw-Huron interlobate moraine in Steuben, Dekalb and Noble Counties. The remarkable accummulation of bowlders in the Wabash-Erie channel at and above Huntington may indicate the point where that channel cuts the Salamonie Ridge. The Wabash River probably cuts the Mississinewa Ridge near LaGros. Without having examined every mile of the ground, the writer deems the evidence sufficient to justify the statement of the following conclusions:

1st. The Wabash-Erie channel between the Ohio State line and the west line of Wabash County cuts through four morainic ridges at regular intervals of 12 or 15 miles.

2d. In passing the ridges its direction is from east to west; between them from northeast to southwest.

3d. The principal non-axial streams of the Wabash-Erie region flow along the outer faces of terminal moraines of the Huron-Erie glacier.

If Chamberlain's distinction be maintained and the word *terminal* be used to designate only that moraine which marks the extreme limit of the ice sheet, then the Wabash-Erie ridges are *peripheral* or *frontal* moraines. They probably belong to the later stages of the second glacial epoch, during which, according to Chamberlain and Salisbury,* there was a succession of glacial retreats and re-advances; and who can assert with any confidence that they were not made by the advance of four distinct and successive glaciers, and are thus *terminal* in the strictest sense? It seems more probable, however, that they are moraines of recession and mark halting places in the retreat of one and the same ice-lobe. When their uniformity of mass, strict parallelism and occurrence at regular intervals are taken into account, the whole arrangement will perhaps prove to be unique among the glacial phenomena of North America. Their greatest importance lies in the evidence which they afford of regular periodical oscillations of climate. The outer edge of the ice-lobe occupied a certain position long enough to form a moraine five miles wide and 100 feet high; it then fell back fifteen miles and occupied another line long enough to form a similar moraine. These alternating halts and retreats were repeated four or five times, the last retreat being 30 miles, and the last moraine, the Blanchard ridge of Winchell, being smaller and less symmetrical.

The general interpretation of the phenomena of the drift in the Wabash-Erie region is obvious. A portion of the great continental ice sheet, driven against the hard limestone of northwestern Ohio, emerged from the Huron-Erie basin and deployed upon the plain to the southwest. It was compelled by a *vis-a-tergo* to move up a gentle slope, and like a

*6th Annual Rep. U. S. G. S., p. 315.

mountain stream which has reached the plain, it ceased in great measure to erode its bed, and, to a corresponding extent, began to deposit its accumulated materials. The deep and comparatively uniform mass of drift in northern Indiana bears the relation of a delta to the ice stream. That deposit took place by simultaneous surface melting, ground melting and interior decay is a conclusion almost unavoidable. To suppose that *a glacial condition of climate* ever actually existed in Indiana is as unreasonable as to suppose that it now exists at the *foot* of the Alps. If such had been the case the ice mass would have been thickening in this region instead of thinning, and would have extended far south of the Ohio River. The moraine material of Western New York, Wisconsin and other localities has exactly the appearance of having been *dumped* from above, and its contours could be easily imitated by depositing upon a nearly level surface successive loads of sand, gravel and clay, the loads being extremely variable in size and placed at very irregular intervals. This would necessitate a great relative thickness of ice and the existence of much surface debris. In the Wabash-Erie region this tumbled topography is nearly wanting, and the uniformity of surface, broken only by the long, symmetrical slopes and curves of the moraines, indicate that the ice sheet was comparatively thin, and that its deposit was chiefly subglacial and marginal. The first glacial mass rested upon and passed over the bed rock, forming the characteristic striæ found in so many localities. In consequence of *an ameliorating climate about the sources of the ice-stream* in the northeastern part of the continent, that stream dwindled in size or disappeared entirely. Upon the recurrence of glacial conditions another invasion or invasions occurred from the same source. Whether the glacier which formed the Wabash-Erie moraines was the second or the twenty-second it may be now impossible to determine. Whatever the number, each would obliterate, as far as it went, the distinctive traces of previous glaciers, and each would pass over, push along, heap up and rearrange the material left by its predecessors. The outline, directions and extent of the last one are revealed by the moraines. The southern portion was allowed to expand with considerable freedom, but on the northern side of the trough in Indiana it met some obstruction, probably the lateral edge of the Saginaw glacier, by which it was crowded back and heaped up, and the principal axis of flow was thrown ten to twenty miles south of the axis of the trough. During the melting of the ice certain great drainage channels were kept open by the floods of water, such as the Wabash-Erie channel, the gorge of Cedar Creek, and others which cut directly through the moraines. At the same time temporary lakes, extra, intra and inter-morainic were formed, the most considerable of which, the Maumee Lake, lay at first between the St. Mary's and St. Joseph moraine and the retreating edge of the glacier, afterward between that ridge and the Blanchard moraine. When the ice dam had retreated to a position near the present foot of Lake Erie, the Van Wert and Hicksville ridge may have been, for a short time, the shore of a body of water which included both Lake Erie and Lake Huron, and stood at a level about 200 feet higher than those lakes do at present. At that stage the Maumee River, of course, had no existence, the principal drainage system being the St. Joseph-Wabash, into which the Maumee-Erie lake discharged at Ft. Wayne, and to which the present St. Mary's upper Wabash, Salamonie and Mississinewa were unimportant tributaries.

PRE-GLACIAL GEOLOGY.

Concerning the rocks which immediately underlie the drift in Allen County very little is known. In the southern part they are probably upper silurian of the water-lime or Niagara group, and in the northern part almost certainly devonian, Huron shale and Corniferous limestone, but the position of the partings is purely conjectural. The chapter upon outcrops in Allen County is as short as the famous one upon snakes in Ireland. Rumors have been afloat of the existence of quarries in several localities, but upon the spot they have proved to be doubtful or wholly mythical. In 1860 Richard Owen, then State Geologist, visited a quarry in the northeast quarter of section 35, Adams, and reported the evidence as being indecisive in regard to the geological horizon of the rock.*

A search of this quarry resulted in the discovery of a "wallow-hole" in a pasture, three feet deep and twenty in diameter, where numerous small fragments of limestone were imbedded in the mud. The owner of the farm, Mr. A. J. Akey, said he had obtained from it stone enough for the foundation of his house, also several piles which lay in his yard, and that it was originally in slabs six feet by ten and eight to twelve inches thick. The fragments found were crystalline and fossiliferous brown limestone, with bituminous liguilitic partings. One small fragment shows a perfectly glaciated surface. Of the fossils, only *strophodonta profunda*, *spirifera radiata* and a gibbous *orthis* were recognizable. In the uppermost rock borings from an artesian well in White's addition, Fort Wayne, occurred a few fragments of black shale (Huron); it is probable that Fort Wayne is situated very near the boundary between the silurian and devonian beds.

Of deep borings in Allen County there are nine (to September 1, 1888), six being within the limits of the city of Fort Wayne, and three within a radius of four miles from the city. The first well was sunk for artesian water in the Court House square in 1875, but without success. The others have been drilled within the past three years in the search for natural gas. They all pass through the same strata and show only trifling variations of thickness and level.

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*Ind. Geological Report, 1859-60, p.

SECTION OF "ARTESIAN WELL" BORING, COURT HOUSE SQUARE, FORT WAYNE.

Surface of ground			772 feet above sea level
Drift	88	feet to	684 " " "
Limestones (Niagara)	802	"	118 " below "
Gray shales (Hudson)	260	"	378 " " "
Black shales (Utica)	260	"	638 " " "
Limestones (Trenton)	1,590	"	2,228 " " "
Total depth	3,000 feet.		

Sections of several other borings are practically identical with this, and the extreme variations from it may be accounted for by differences in level at the surface, which at other wells has not been determined. The results, so far as gas is concerned, are practically negative, one well, near the Berghaff brewery, furnishing gas enough to run an engine, the others none. The citizens of Fort Wayne have expended $20,000 in the effort to obtain natural gas; they have persevered in spite of discouragements from the beginning; the territory in the immediate vicinity of the city has been thoroughly tested; further attempts seem hardly justifiable and probably will not be made. At the same time it is being demonstrated that a city surrounded by towns with gas can be prosperous and enjoy a rapid and healthy growth without it.

A boring near the bank of the Maumee River, in White's addition, proved to be a genuine artesian well, and furnishes a large quantity of excellent water, which is at present unutilized.

Partial analysis of the water gives the following results:

Temperature in January	49° F.
Temperature in August	53° F.
Total solids in 1 wine gallon	32 grains.
Calcium carbonate	20.2 "
Calcium sulphate	0.9 "
Magnesium carbonate	8.5 "
Ferreous carbonate	1.7 "
Sodium chloride	0.7 "
Hydrogen sulphide	0.4 cub. in

ECONOMIC GEOLOGY.

Aside from numerous brick and tile works, and the excavation of moulding sand, there are no industries in Allen County dependent upon its geology, except agriculture. Although the extremes of level differ by not more than 150 feet, there is a considerable variety of surface, soil and natural products. The land may be divided into four classes,

1. *Lacustrine Land.* Lake bottom without muck. Soil clay, sometimes laminated, with occasional streaks and ridges of sand and gravel. Drainage difficult.

2. *Bottom or Muck Land.* Marshy prairies, occupying old drainage channels and the basins of extinct lakes. Soil black and mucky.

3. *Moraine Land.* High and rolling. Soil gravelly clay, with mounds and ridges of sand and gravel. Drainage easy.

4. *Inter-Moraine Land.* A combination of the other three, chiefly flat and low, resembling No. 1, but embracing large tracts of No. 2, with occasional areas of very subdued morainic type.

The location and limits of each of these classes have been sufficiently indicated in the foregoing description. Evidently, to the people of Allen County the subject of drainage is one of the very first importance, and perhaps in no other county has drainage been undertaken upon a larger scale. Numerous ditches intersect every township, and nearly every natural water-course has been improved for the purpose. The most extensive work of this kind is involved in the drainage of the large tracts of marshy prairie which exist in the county. The Eel River ditch, completed in 1887, is 11 miles long, and drains 3,000 acres in Lake and Eel River townships.

The drainage of the Little River Prairie, which occupies the Wabash-Erie channel, in Allen and Huntington counties, is a project which has been long contemplated; but the magnitude and difficulty of the undertaking were such as to defer effectual effort until the year 1881, when a bill was passed by the Indiana Legislature authorizing the survey of all large bodies of marsh land in the State.

Under this law a survey of the Little River region was made in 1882, by Dr. John L. Campbell, of the United States Geodetic Survey. His report to the Governor strongly recommended its drainage. In 1883 a number of interested landholders filed the proper petition, and after the necessary surveys and legal proceedings, a plan of drainage was finally adopted in 1886, which provides for a main ditch twenty-six miles long, with branches, which raise the aggregate to forty miles, the different portions varying in width from four to thirty feet. Outlet is thus furnished for the water which falls upon more than 200,000 acres of land; 35,000 acres of marsh will be converted into rich farming lands, and a prolific source of miasma will be removed, greatly to the improvement of the sanitary conditions of 50,000 people. The total expense of the undertaking will be about $170,000, and the amount which it will add to the wealth of the community is estimated at $320,000. The whole work will be completed in 1888.

NATURAL HISTORY AND ARCHÆOLOGY.

The fauna and flora of Allen County have not been studied in the thorough and systematic manner which their variety and importance deserve. The county was originally covered with a dense forest of oak, walnut, hickory, beech, maple, ash and elm. A few tracts of the primitive woodland still remain, and the rivers are bordered by as fine specimens of elm, cottonwood and sycamore, as can be found anywhere. Chestnut, pine and hemlock are entirely wanting. The tamarack flourishes upon the site of extinct lakes, and some of the bluffs of Cedar Creek are still covered with white and red cedar, *Cupressus thyroides* and *Juniperus virginiana.* The variety of soil offers favorable conditions for the growth of a great variety of plants. The Little River Prairie alone constitutes a botanical garden of no mean proportions. Enough has been done to show that the plant list of Allen County when completed will at least equal that of any other county in the State.

Of tbe numerous wild animals which once made Ft. Wayne an important fur-trading post, the largest, including the deer, bear and wolf, are nearly extinct. Occasionally a hunter's story of having seen or shot a deer or a bear in the black swamp, near the Ohio line, gets into the newspapers. Numerous dams still remain as monuments to the beaver. The wild turkey and the golden eagle are occasional visitors. Of semi-fossil remains, a single mammoth tooth, and portions of the skeletons of five mastodons have been discovered in various parts of the county. The plants, insects, mollusks, fishes, reptiles and birds offer to the naturalist a promising and but partially worked field.

The Mound-Builders left but scant traces of their occupancy in Allen County. Col. R. S. Robertson, of Ft. Wayne, who is an authority upon the subject, reports the existence of mounds or earthwork at seven points along Cedar Creek and the St. Joseph River, but none in the southern part of the county. The usual implements and ornaments belonging to the stone age are plentiful in many localities, but the writer is not aware that anything which throws new light upon the subject has ever been discovered in this region.

SECTION OF WELL BORED BY W. T. ABBOTT AT FORT WAYNE, INDIANA, 1888.

Drift	106 feet.
Limestone	868 "
Shale	176 "
Black shale	257 "
Trenton limestone	493 "
Total depth	1,900 feet.

The well filled with mineral water from the bottom up to about 900 feet.

Report of analysis of mineral water from well of W. T. Abbott, by Chas. R. Dryer, M. D., analytical chemist.

Specific gravity at 18° C. (66° F.) 1.04 Reaction alkaline.

	Parts per Million.	*Grains per Wine Gallon.*
Sodium chloride	51,250.	2,993.793
Magnesium chloride	2,551.	148.825
Magnesium sulphate	2,456.	143.283
Calcium sulphate	355.	20.71
Calcium carbonate	10,240.	597.401
Potassium bromide	93.75	5.469
Ferrous carbonate	362.	21.119
Silica, alumina and organic matter	750.	43.755
Nitrates and phosphates	Traces.	
Total solids	68,057.75	3,974.355
Carbon dioxide	2.31 cub. in. per gal.	
Hydrogen sulphide	2.3677 " "	

PARTIAL REPORT OF SURVEY OF THE WESTERN DIVISION, INCLUDING SKETCHES OF PULASKI AND WHITE COUNTIES.

BY W. H. THOMPSON.

The work of examining the counties included in the Western Division, as indicated by the Chief of the Department, has been prosecuted as the fund at hand permitted. It is not yet finished, and it would be premature to make at this time anything like an extended report. The discovery of natural gas in the State necessarily changed the plans of the Department and turned its attention to a search for that valuable deposit, hence a large area of country which had already been surveyed by former State Geologists had to be gone over again in order to locate approximately the surface under which gas discoveries might be expected. This stopped the work which was going on in and near the Kankakee Valley and turned the attention of the assistants in the field to an area further south and east. My own work and observations, therefore, have been largely directed to the question of natural gas developments, and consequently much less than I hoped to do has been accomplished in other directions.

At present the area in Indiana under which the supply of gas is of paying value, may be said to lie within a well-defined circumference, and it is not to be expected that any great discoveries remain to be made in this connection. The State Geologist has refrained from discouraging the sinking of wells, even where it was not thought that they would be successful, for it was desirable that the popular feeling for investigation should take its course and fully exhaust itself, in view of possible discoveries. The result has been the piercing of the stratified rocks in the immediate neighborhood of almost every town in the State. The gas field has been pretty thoroughly explored, and incidentally we have obtained a most interesting and instructive view of the strata down to the horizon of the Trenton limestone. Meantime, however, the work of collecting facts relative to other features of the State's geological formation has been progressing as fast as circumstances would permit. Possibly, even probably, those things which form the smallest part of a report made for popular reading, information and instruction are those which convey the gist of what scientists would care most to know, and indeed, outside of the discovery of natural gas and the tremendous impulse it has given to the manufacturing interests of our State, there is nothing of a sensational nature, in our geological observations, to either scientist or unlearned citizen. Still the work must prove of great value to the people, not so much as a record which will immediately chain their attention, but more as a widely disseminated and authoritative advertisement of the mighty resources of our great commonwealth.

The chief question of interest to the scientific world, and which will be reported upon so soon as the survey of the western division shall be completed, is connected with the great moraine of the northern part of the State, and with the ancient shore-line of Lake Michigan. Much work has already been done in the way of preliminary expeditions and explorations for the purpose of securing an outline of the chief features and of the general contour of the areas to be studied. This work can not be included in this report, because it is not yet sufficiently advanced to render the step advisable or profitable, as a report now would necessitate a reiteration of its facts in the next volume at great expense, and without any corresponding value to the people. It has, therefore, been thought advisable to defer an extended report upon the western division until the work has been measurably completed.

The particular counties, surveys of which will affect the study of the ancient shore lines of Lake Michigan, the area drained by the Kankakee River, and the northermost morainic formations in the northwestern part of the State, are: Jasper, Pulaski, Fulton, Marshall, Starke, St. Joseph, Elkhart, Laporte, Porter and Lake. Through the region occupied by these counties the Kankakee River flows in a general direction somewhat southeasterly, and the stream is bordered by wide marshes and wet prairies, which makes it quite difficult to survey. It is, however, the most interesting region in the State, and one which offers great returns for intelligent observation and labor. The well known "swamp lands" of the Kankakee must some day be drained, and it would appear to be the duty of the State to have a proper survey made with a view to ascertaining the most practicable and the cheapest plan for doing this. It would be much easier and cheaper to make this survey in connection with the geological examination now progressing than it ever can be hereafter. At a comparatively small additional expense the State Geologist could direct both surveys at once, and at the same time make each a great help to the other. This would not only outline all the deposits accurately and locate them distinctly, but it would give levels and indicate lines of drainage of immense value to all the people in the counties adjacent. It is quite plain to one having a knowledge of engineering that a large part, if not the whole, of the area now lying useless, thousands upon thousands of acres, might be reclaimed easily and at comparatively small expense, if the proper lines of drainage were first located. It is not a pleasing commentary upon the enterprise and forethought of our State that in one of its fairest and, potentially, most fertile areas there lies a vast waste, given over to the frog, the snipe and the heron, the lily-pads, the water grasses and the stagnant pools, when energy and the intelligent application of well known methods would make it almost a garden spot. On the other side of the Kankakee valley, after leaving the marshes, we find excellent grazing and farming lands. Indeed, much of the swamp land is used for meadow and for stock grazing in the dry seasons. In many places the lowering of the water level a foot or two would reclaim many hundreds of acres, making most excellent pasture lands.

Contrary to what might be expected of a region so marshy and interspersed with stagnant ponds and lagoons, the whole Kankakee region is a healthful one. There is less malaria in the midst of this vast swampy waste than there is in some of the most thickly settled parts of the State. This favorable condition may be due to the iron in the water and to the strong and almost constant wind currents which in summer and autumn sweep over the region from the lakes on the north and from the high prairies on the west. Be this as it may, the Kankakee River has long been a summer resort for those seeking health and out-door recreation. Excellent boating, fishing and shooting add charm to the solitude and salubriousness of the region. The river itself, though not a large one, is beautiful, winding through its marshes, its groves and its giant grasses and among its wooded islands. Here and there it spreads its channel and becomes a lovely, lily-fringed lake. Its bed is in the blue bowlder clay from its source to near Momence, where the stratified rocks appear at the surface forming a great dam across the course of the stream. North of the river I have not found, as yet, any outcropping of paleozoic strata. Many deposits of bog iron ore and a few chalky formations are the only mineral features promising commercial value. I think it quite probable that there may be discovered large quantities of clay of a quality suited to coarse pottery manufacture.

It will be a very tedious process by which the work of the survey must be done in all this region. Much of the surface is almost impassible save in the dryest season, and even then its nature is such that the progress of examination is necessarily very slow. The whole area is rich in botanical interest, and the final report upon it will, it is hoped, have its value as a contribution to the study of our middle western flora. So far the notes of the region point to some exceedingly curious and interesting discoveries touching the migration and the nesting habits of aquatic and semi-aquatic birds, a subject at present engaging the attention of scientists everywhere, But, to my mind, the chief value of the survey to the people of the area to be examined will be its bearing upon the question of the drainage and reclamation of the wet lands. Certainly this is a matter of largest importance to a great number of our citizens, and it should be a subject of earnest consideration in the minds of our legislators. If, in connection with the survey there could be a set of levels taken by which the valley of the river and the contour of its surface could be outlined, we should have the best possible basis (at the least possible cost) for any future draining operations. A line drawn through Laporte, Valparaiso and Crown Point would roughly indicate the northern limit of the Kankakee valley, while on the south the boundary line lies irregularly from six to twenty miles distant from the stream. This may be justly named the youngest valley in the State, as its formation is wholly post-glacial. It may, however, simply mark the approximate line of a very ancient stream. As I have said, its entire depression is in the drift matter, the bottom of the river channel being often from one to three hundred feet above the surface of the stratified rock. The wells bored in the region indicate that during the glacial period a lobe of the great glacier followed the course of the northern side of a ridge (or upheaval which had occurred at about the close of the Niagara period), and left upon its withdrawal a deep irregular deposit of till or bowlder clay filling the ancient channel. On either side of the river, at unequal distances, the stratified rocks when reached in wells show the effect of erosive agencies having a tremendous power. Moreover, the sudden alternations of geological horizons indicate that superior strata have been non-conformably deposited upon the Niagara rock, which is greatly disturbed and displaced by faults, conical uplifts and short, steep monoclines.

As the State Geologist himself has observed in another paper, the wells bored near Francisville plainly show these conditions and what is true of that special area is more or less true of a very large region so far as we have data on the subject. It would appear probable, that when all the facts shall have been collected and digested we shall find that the Niagara upheaval across Indiana is part of a great continental lift which has served to divide the two great coal basins, (that of Michigan and that of Indiana) from each other, and that on either side of it the strata superior to the Niagara will be found to rest nonconformably against the inclines of that broad gentle upheaval. This of course is speaking generally; the details, if traceable, would show every shade of departure from the strict general rule. The apex of the great divide has been ground off by glacial action and many curious outlines have been left, notably the sandstone deposit near Rensselaer, which has every appearance of having been transported bodily to its present situation by some agency of incalculable force and of a peculiar nature. Evidently this sandstone is not in place; all its surroundings clearly show this. It lies on the highest part of the region in which it is found, it is true, and has under it an older formation, but the rock immediately below it is not the proper geological substratum of this sandstone, it appears; it is the corniferous limestone of the Devonian age, and is cut and channeled by the glaciers. Professor Collett reports the surface of this sandstone as showing the striæ and planing action of ice. This could be and would be true even if the whole had been transported to its present site by glacial action. The frequent withdrawals and returns of the ice during the glacial period had the effect of so many glaciers. At another place I have described this very interesting and curious feature. Quite different from this are the deposits of Devonian black shale and Corniferous limestone found in the lower areas of this region with cones and ridges of the Niagara rock lifted up between. A little farther south than the limit proper of the Kankakee Valley the subcarboniferous rocks are found here and there laid down conformably on the Devonian black shale.

One of the marked features of the whole northeastern area of the State is the varied and picturesque deposit of sand. This is a fine silicious body, of a pale buff color, which in the vicinity of the shores of Lake Michigan takes on the form of shifting cones and ridges. The ancient shore line, or rather lines, each of which probably marks a former limit of the lake's waters, have not yet been traced and outlined sufficiently to be reported here; but evidence is in hand which will probably show that that there has been from two to four, and possibly five, distinct, well-marked recessions of the water since Lake Michigan took substantially its present form. The examinations have not been full enough to justify an opinion, even of a provisional sort, as to whether these retrogressive movements have been sudden and cataclysmic, so to speak, or whether they have been slow and gradual. The general shape of the lake appears to have been much the same at its southern extremity during all the vicissitudes of its past history, as the ancient shore lines are practically parallel with the present one.

Coming to speak more particularly of the immediate channel of the Kankakee River, the first thing to be noted is the frequency of the changes which have taken place in its course and locus at various places. The fall is slight throughout the river's length in Indiana, and the sluggish current has frequently filled its channel with silt and sought a new course by washing out another, and often by a more roundabout way. Some of these old channels are still observable in the marshes, where they appear as long, shallow, stagnant lagoons filled with aquatic plants, the haunts of large wild fowl and various species of the smaller game birds. The present course of the stream is very crooked, in places almost doubling on itself, and to this fact may be referred, in a large degree, the wide overflows which occur in certain localities during the spring and autumn freshets. The water of the river, especially when low, is perceptibly affected by the presence of salts of iron, the oxide of which colors it a pale ochreous yellow. Most of this iron is from springs and slough-streams that rise through ferruginous deposits.

The immediate banks are usually very low and covered with a dense growth of plants of various kinds, chiefly trees, weeds and grasses, but, as might be expected, the soil is mostly a light sandy alluvium with a large per cent. of vegetable matter. This soil, when drained, would at first be too porous, but it would gradually become more and more compact and fertile as the process of oxidation and chemical change went on, a process which could be materially assisted by the addition of lime. I do not hesitate to say that a large part of what is now the most worthless part of these Kankakee marshes would become, under a properly directed system of drainage, one of the richest areas in Indiana. Every element of fertility is present in exhaustless supply, and nothing save the superabundance of water keeps it in its present state of desert and uninhabited wildness. By straightening the course of the river and constructing a few ample cross drains the whole valley would be turned into a rich and desirable farming region. As to the cost of such a work, I have no basis for an accurate estimate, but a long experience in engineering teaches me that it would be far below the value of the benefits that would accrue to the lands. Indeed, there is not now anywhere in the country an enterprise which would bring a better return for intelligent management and judicious expenditure of labor and money. It is a work that must and will be done, and the sooner the better for the reputation as well as for the happiness and general welfare of the people.

It is preposterous to suppose that in the heart of Indiana an area of rich and valuable lands almost as large as the State of New Jersey is to be left much longer in an utterly waste and desolate condition when a little enterprise would make it one of the fairest parts of the State. Even should the undertaking finally cost more than the actual enhancement of the value of the real estate, it would be commendable for the State to remove the stigma attaching to her reputation on account of such a blot upon the face of her domain.

The botany and zoölogy of the Kankakee region will prove of great interest when it shall have been fully studied and arranged. A great mass of notes has been collected already; enough to show how rich will be the returns for labor expended in this direction, and of what value to science and general education the careful study of even limited areas of undisturbed nature may be made by placing the results in a form readily accessible to all who may be interested.

At various points in the Kankakee region persons have reported the discovery of coal, but there is no coal. The black shale of the Devonian formation is often quite bituminous, and will then burn with a clear flame not unlike that of cannel coal. Fragments of this rich black shale have been found in the drift, hence the mistake. Coal can not be found here. The beds of iron ore are of excellent quality, being massive deposits of gray-brown bog concretions. The time may come when these will be of immense value.

The following pages contain a general sketch of the geology of White and Pulaski Counties and a few notes on the Tippecanoe River, but by far the greater part of the field notes made in this region have been retained for a future report or have been used by the State Geologist in other papers contained in this volume. It will require at least two more years to get together all the facts for a full report of the Kankakee and the region which should be drained by it.

WHITE COUNTY.

This is one of the new counties of Indiana which, by virtue of its fertile soil, excellent location, and the energy and intelligence of its inhabitants, is being rapidly developed into one of the most prosperous divisions of the State. It is bounded on the north by Jasper and Pulaski counties, on the east by Cass and Carroll, and on the south by Carroll and Tippecanoe, and on the west by Jasper and Benton counties. The general surface of the ground is very level, and though drained by a large number of streams the soil is too wet for successful cultivation without a large amount of artificial drainage. The basis for a thorough system of drainage is supplied in the large number of natural streams by which the surface of the county is channeled in almost every direction. Chief of these streams is the Tippecanoe River, which enters the county from the north, flows in a southwesterly direction for eight miles to the south line of Liberty township, thence a little east of south to the town of Monticello, and thence almost due south along the eastern line of the county to the north line of Tippecanoe County.

This river has carved for itself through the county a wide and deep valley, and into it all the other streams of the county empty themselves.

The Big Monon Creek enters the county from the north at a point six miles west of the Tippecanoe River, and flowing thence south for four miles to its confluence with the Little Monon Creek, then runs to the southeast and in a course of two miles falls into the Tippecanoe.

The Little Monon Creek, above referred to, rises in Benton County and flows for fifteen miles in a generally northeasterly direction through White County to the town of Monon, whence it runs east and then southeast to its junction with the Big Monon Creek.

Honey Creek rises in West Point Township, within a mile of the Little Monon, and flowing thence northeast for three miles almost parallel with the Little Monon, turns due east and runs into the Tippecanoe River three miles below the mouth of the Big Monon.

Big Creek rises near the west line of the county, only a short distance south of the head waters of the Little Monon, flows east through West Point Township, and two miles into Big Creek Township, thence by a long, sweeping curve through a course north, northeast, southeast and south, it empties into the Tippecanoe River.

Indian Creek runs west along the north line of the county to its junction with the Tippecanoe, and other streams flowing from the east empty into the river above the Norway Mills.

In the south several streams carry the surface water from Prairie Township into the river. Few counties in the State are so well supplied with flowing water, and few level and humid sections of the country are so well furnished with natural drains.

These streams are generally bedded in the drift deposit which covers the whole of White County, though in the northwestern part of the county the Little Monon Creek, and some others of the small streams run over a floor of the Niagara limestone, and at a few points, from Flowerville south, the Tippecanoe River cuts through the drift and exposes the Devonian shale. All these streams lie sufficiently below the general surface of the surrounding country to give abundant fall to such lateral ditches as shall be constructed in any proper system of drainage, and capital and energy only are required to render the lands of this county fruitful to a degree scarcely to be measured.

HISTORY.

This county formed a part of the ancient domain of the Pottawattomie Indians, though the Miamis claimed the land by right of temporary occupancy. The former nation was, however, in possession when the whites began to explore the country, and it was with the Pottawatomies that the General Government treated, when on the 2d day of October 1818 that tribe ceded to the United States all that tract of country situated within the bounds following: "Beginning at the mouth of the Tippecanoe River and running up the same to a point twenty-five miles in a direct line from the Wabash River, thence on a line as nearly parallel to the general course of the Wabash River as practicable to a point on the Vermillion River twenty-five miles from the Wabash River, thence down the Vermillion River to its mouth, and thence up the Wabash River to the place of beginning." This included the greater part of what is now White County. The remainder of the territory now contained within the limits of the county was added by the terms of a second treaty executed on the 16th day of October 1826. By that treaty the Pottawatomies ceded the lands bounded as follows:

"Beginning on the Tippecanoe River where the northern boundary of the tract ceded by the Pottawatomies to the United States at the treaty of St. Mary's in the year 1818 intersects the same, thence in a direct line to a point on Eel River half way between the mouth of said river and Parish's Village, thence up Eel River to Seek's Village (now in Whitley County) near the head thereof, thence in a direct line to the mouth of a creek emptying into the St. Joseph's of the Miami (Maumee) near Metea's Village, thence up the St. Joseph's to the boundary line between the Ohio and Indiana, thence south to the Miami (Maumee), thence up the same to the reservation at Fort Wayne, thence with the lines of the said reservation to the boundary established by the treaty with the Miamis in 1818, thence with the said line to the Wabash River, thence with the same river to the mouth of the Tippecanoe River, and thence with the Tippecanoe River to the place of beginning."

It was several years after these treaties before the Indians were removed to the Indian Territory, and the lands of the county were not opened for entry until in November 1829, and many sections were not opened for entry until 1839.

No sooner were the entry books opened than the pioneers began flocking in, and as early as 1833 the Legislature was asked to have a new county located and organized, and on February 1st 1834 the act constituting and defining the limits of White County was approved. The name assumed was in honor of Major Isaac White who was killed in the battle of Tippecanoe. The large section of country now comprising the counties of Jasper, Newton, and portions of Benton and Pulaski, by legislative enactment remained attached to White County and it was only by the constitution of Benton County in 1840 that the County of White was circumscribed by its present boundaries.

Like most of the northern counties of Indiana its march toward settlement, cultivation and prosperity has been very rapid. In September, 1834, the county seat was established by three commissioners, John Kilgore, John B. King and James H. Stewart, on the west bank of the Tippecanoe River, and named the place Monticello, as they declared "after the home of the great disciple of human liberty, Thomas Jefferson."

The lands of the county are generally level, but greatly diversified in appearance, portions being prairie, other portions oak-openings, while some tracts are heavily timbered. The soil is mostly a heavy black muck or mold, requiring drainage to render it fit for cultivation, though across the north side of the county may be seen in many places those singular ridges of fine yellow sand, which in ever increasing size and number dot the prairie northward to Lake Michigan. These ridges of sand are generally thickly covered with a forest of small oaks, and greatly enhance the beauty of the landscape when summer has cloaked them with her heavy green mantle.

A difference of opinion exists as to the origin of these sand hills, but the better argument is in favor of the transporting agency of the winds.

It seems probable from the surface evidence that Lake Michigan once extended very much farther in a southeasterly direction than it now does, but whether this be true or not, the fine lake sand which forms these long parallel ridges evidently owes its separation from the bowlder drift to the restless waves of that great lake. The process of expulsion from the lake may be seen now constantly going on at Michigan City. The prevailing winds from the northwest roll the sand-bearing waves ashore; the sand is deposited as the wave halts and recedes, and the wind, catching the fine grains of sand, whisks them up and over the shore hills and away across the level lands of the interior. In time of a strong and equal blowing wind a delicate veil of sand may be seen floating like a gauze streamer from the top of any exposed sand hill on the southeast shore of the lake.

It is true that the lake sands are not now rolled so far inland as we find the ancient deposits, but it should be remembered that the conditions are now different. For ages after the deposit of the cold bowlder drift and the retreat of the great ice cap there was neither vegetation nor other obstruction to the free rush of the winds. And how they must have played over this great floor! The shallow waters of the lake extending far into the interior of Indiana were stirred to the bottom. The fine sand was lifted like dust and tumbled into ridges. Shore line after shore line marks the recession of the water, and between these shore lines the sand dunes lie where the waves of the wind have heaped them. Below these sands the glacial drift overlies the rock throughout the whole of White County in varying depth, from a mere film at Monon to a depth of nearly three hundred feet in the northeastern portions of the county. The power of the ice during the glacial period to plane down the inequalities of the earth's surface, no matter how refractory might be the material obstructing its flow, is well exemplified by a late exposure of the Niagara rocks near the town of Monon. At a point about a half mile southeast of the town the Indianapolis division of the Monon Railway (the Air Line) crosses the Little Monon Creek on a low trestle, and in approaching the creek from the south side ditches have been cut almost down to the surface of the rock. Late floods of rain have washed out these ditches near the mouth to such an extent that a floor of the limestone has been laid bare thirty feet in length by ten feet wide. This floor is planed smooth as glass save for the striæ marking the surface from north to south, indicating the direction of the ice flow.

How much of the top of the broad cap of Niagara limestone which rises almost to the surface of the ground in the western part of this county has been planed off, ground to powder and mixed with the bowlder drift can not be known, but the resistless force of the moving ice cap is perfectly attested.

So great is the mass of bowlder drift in the northeastern portions of the county that but little can be learned as to the character and condition of the surface rocks. The few bores that have reached the stratified rocks in that section have found the Devonian shale, and as the same rocks were found at Monticello and outcrop both above and below that place in the bed of the Tippecanoe River. there is little doubt that rocks of the Devonian period underlie the glacial drift over nearly the whole of the northeastern half of the county. Across the southwestern angle of the county the stratified rocks below those of the Devonian period have been upheaved. By this upheaval the Niagara rocks, which at that time were the surface rocks, were wonderfully shattered and the fragments tilted in many different directions. The crown of the upheaval in this section lies in the vicinity of the town of Monon, extending from a point one mile south of the railway crossing to a point two miles north of Francisville, in Pulaski County, and thence in an irregular line to the west to a point northwest of the town of Rensselaer, in Jasper County. The summit of this crown was pierced by the old well on the "Blair farm," and there the limestone was overlaid with only a shallow cloak of drift, a half dozen feet in thickness. Indeed, at several points on this farm the Niagara limestone appears above the soil.

After the upheaval of the older *strata* of the sedimentary rocks the various strata of the Devonian rocks were deposited, and wherever found in place the lowest *stratum* of the later period may be found so embedded upon and against the up-tilted and broken rocks of the older deposit as to furnish indubitable proof of the ancient disturbance of the lower stratifications.

The advance of the great glacial plane found this elevation of the lower rocks an obstruction in its path, and with a power irresistible, and indeed unimaginable, shoved off the crown of the arch, paying as little heed to the refractory limestone as to the friable shale. The exposed limestone in the bed and banks of the Little Monon Creek at the crossing of the Louisville, New Albany & Chicago Railway, a quarter of a mile south of the town of Monon, and which extends down the course of the creek for a mile to the east, is massive in formation, of excellent quality for the lime-burner's use, and is easily quarried, as the thin overlying drift is but little hindrance to immediate blasting.

For many years this stone has been burned into lime at the railway crossing, and an excellent lime has been produced, of much the same character as the well known Delphi lime. This rock is unusually full of fossils, and holding so much oil as to greatly aid in the process of burning. The rock is quarried in the bed of the stream and is freed by the bar without blasting, coming away in flakes and triangular blocks, the crevices filled with a heavy oil by which the rock is much discolored. Little attempt has been made to utilize this limestone for building purposes, and not much can be said in its favor in that behalf. For foundations, culverts, and for abutments for bridges and backing for range masonry it could be safely and effectively used, but it is not to be recommended for walls requiring faced stone. Indeed the difficulty of properly dressing the stone to uniform thickness, coupled with the shattered condition of the upper strata, render it unavailable for good range work. It would be interesting to know just what the surface conditions of the earth at this point were at the time of the great north and south ice flow, which crawled across this region pushing its mighty plane before it, and by virtue of its enormous weight shearing away the obdurate limestone with the same ease with which it leveled the domes of sand.

It is not possible for us to now determine just how much of the upper Silurian rocks has been thus removed, nor can we say with any approach to certainty to what depth the rocks of the Devonian period were originally deposited at this point. The evidence now obtainable points to a solution more curious than valuable, and one which may be greatly modified by a careful examination of the regions lying farther north. It appears that at the end of the period in which the Niagara rocks were deposited there was, in this region, an upheaval which lifted the then surface rocks to a point somewhat higher than at present found, the crown of the arch along the axis of upheaval passing through White County from northwest to southeast, the highest point being near the present town of Monon.

The Devonian seas, deeper to the southwest and to the northeast, scarcely over-topped this ridge of Silurian rock, and the sedimentary deposit of the Devonian age but lightly covered the Niagara rocks. Whether the seas of the carboniferous period reached so far north and east, or rose to such a height as to cover this ridge with any deposit of even the lowest subcarboniferous stratum, can not now be more than guessed at, for if any such evidence ever existed the ice flow has removed every vestige of it, sparing only occasional patches of the Devonian rocks, and at certain places cutting away many square miles of the upper Silurian rocks. Along the banks of the Little Monon, wherever the surface rocks are exposed, the action of the ice may be observed. At the crossing of the Air Line Railway over the stream, a half mile southeast of the junction of that railway with the Louisville, New Albany & Chicago Railway, the action of the surface water discharged by the railway ditches has denuded the rock for a distance of thirty feet, exhibiting the planished and striated surface precisely as it appeared when the ice retired from it. The *striæ*, beautifully and clearly drawn in unbroken parallels across the whole of the exposed table, bear witness to the persistence as well as power of the leveling force. An iceberg afloat could not by mere impact, however great its weight or powerful the winds or waves by which it was moved, cut away great crowns of obdurate rock, nor groove the wide table with the long parallels of *striæ* as they here appear. Nothing but the advance of the continental ice field could have effected such a work. Moving down with all the resistless force of a growing rock, the enormous ice cap was no more retarded by the most compact limestone than by the softest shale, and taking off the crown of this Silurian uplift, left the superficially lower lying Devonian to the north still in place.

A few miles west of Monon, but in the County of Jasper, the curious feature appears of an out-crop of the massive conglomerate sandstone of the carboniferous age. At what is known as Pierce's quarry, now operated by Mr. James F. Watson, of Rensselaer, this sandstone covers with a cap several feet in thickness a slight swell in the prairie of perhaps thirty acres in extent This stone is not found otherwhere in this region, and appears to be lying far below its true horizon. So little reason is there for its anomalous situation that I carefully examined the field to see if I could discover any evidence of its having been transported in a body by the ice from the north. No such evidence was presented, except, perhaps, the peculiar position of the strata, and this may be as well accounted for in other ways.

This sandstone cap *seems* to be in place, and doubtless is, and the geologist must needs account for its present position by supposing that at one time the ancient carboniferous seas extended at least an arm as far north and east as this locality, and here deposited upon a continental or island shore line the massive conglomerate sandstone where it is now found. Many theories might be advanced, each with some show of support, to explain the manner in which this isolated remnant of the ancient deposits was excepted from the wholesale erosion which removed all other traces of the carboniferous rocks, but it is enough to say that from *some* cause the sullen wrath of the boreal invader spared this little hill-cap as a monument to inform us of the utmost reach of these carboniferous seas.

A careful examination of the quarry revealed a complicated structure of this hill-cap. The opening of the quarry was originally begun near the southern edge of the deposit as it yet exists, and the advancement of the work of removing the stone has been in a direction almost due north for several hundred feet This has enabled us to trace the dip of the strata through all that distance. For nearly the whole distance the dip of the strata is heavily to the southwest. However, at the northernmost point now reached, and which is also the highest point of the deposit, the dip ceases and the strata lie horizontally. The rock is greatly broken up, the crevices extending perpendicularly through all the strata yet exposed, and dividing the stone into cubes, parallelograms, and triangular blocks of such shape and size as to be quarried with much less labor than would otherwise be required.

The quality of this stone is excellent, as may easily be proved by many examples in the neighborhood. The foundations of some of the largest public buildings in Rensselaer came from this quarry, and no stone could better serve that purpose.

The grain of the stone is even and fine, and the clean white color indicates the almost total absence of the iron which is so generally found discoloring the sandstones of the carboniferous age. A slight cloak of drift averaging about four feet in thickness overlies this rock, and in this drift large fragments of the sandstone lie embedded. As this drift is mostly composed of sand and gravel below the surface soil, it would seem to indicate that the action of water must have produced the intermingling of such surface blocks of the stone as had from any cause been broken up, with the glacial deposits in which they now lie embedded.

To what depth this stone extends is not known, as the quarrymen have yet penetrated only to the depth of eight feet, but from the fact that the limestone is reached on every side within a quarter of a mile, at a depth of only four or five feet, it would seem to be certain that the greatest depth of this sandstone cannot exceed twenty feet, and the probable depth is not nearly so great as that. Indeed it is quite possible that the entire deposit is a mass transported here bodily by the ice.

ARCHÆOLOGY.

The mound-builders, who left their traces in almost every county in Indiana, have given us proofs of their presence at many points in White County. In the vicinity of West Bedford, in Monon Township, there are a number of mounds. They are generally small, and appear to have been either sacrificial or memorial, rather than fortifications or places of refuge. Some of these mounds have been opened, and skeletons, stone hatchets and arrow and spear heads have rewarded the explorers. These mounds are generally circular in form, of a diameter ranging from twenty-five to seventy-five feet, and from two feet to ten feet in height. Large trees, varying in diameter from two to four feet grow upon some of the mounds testifying to their antiquity; and whether the builders were the ancestors of the red Indians of later times, or of a different race and lineage, no question can exist that these tumuli were reared at a very remote period of time.

NATURAL HISTORY.

The natural history notes of this county will be found in another paper, and when the ground shall have been fully worked over the report can not fail to have a deep scientific interest. The whole of the Kankakee and Tippecanoe regions will be found surprisingly rich in material both botanical and zoölogical. The ridge or water-shed between the two streams appears to be a meeting place for contending floras, and the waters and wet lands are infested during the spring and autumn migrations with a great variety of alien birds. The fishes and reptiles of the Kankakee and its tributaries have yet to be properly studied and reported. They promise to yield a most interesting return. The means at my command forbade any extensive examinations, and besides my duties for the time lay in the field of geological exploration with natural gas for the objective point, consequently but small attention has as yet been given to the fauna of these waters.

PULASKI COUNTY.

Although the act creating the County of Pulaski was approved February 7, 1835, its organization as a county was only effected by force of the act of February 18, 1839. It is thus shown to be one of the newest counties in the State. Despite many natural disadvantages, which are, however, of a temporary character only, this young county is rapidly developing into a rich, healthful and prosperous division of the State, the home of a contented and intelligent people, who are well aware of the agricultural possibilities hidden in their heavy humid prairie soil and requiring only the ditcher's hand to create fields second to none in fertility. While other older and dryer sections of the State have made wonderful advances in wealth and population, no fair comparison can be drawn between such sections and the heavier level and wet lands of the northwestern portion of the State; and though Pulaski County is yet behind many counties in both public and private improvements, few counties, if any, may justly claim a more rapid and solid progress in material wealth. For it must not be overlooked in any fair comparison that nature, though lavishly endowing her with a fertile and enduring soil, did much to bar her early march to settlement. The county is a great plain, largely prairie, and though traversed by the Tippecanoe River and the Monon Creek from north to south, the one crossing the county through the eastern tier of townships and the other through the western tier, yet the fall of the surface of the ground toward those streams is so slight, and the surface conditions are such that a vast expenditure of money in drainage has been required to render tillage possible.

The great advantages held by other sections of the State over this region in the start of the great race to settlement and civilization may be understood when it is recorded that in the year 1839, only forty-nine years ago, in this whole county, containing four hundred and thirty-two square miles, but thirty-four legal voters could be found.

Yet such has been the change wrought by the energy and intelligence of the settlers that in the year 1888 no less than three thousand votes will be polled at the presidential election. The advance in wealth, education and intelligence has kept pace with the increase of population, and having now barely reached that stage of development when it becomes possible to add the beauties of culture and ornament to the great framework of material prosperity; with a soil of great fertility, an industrious and contented population, and with a position and climate equal to any in the State, it requires no gift of prescience to foretell the steady progress of Pulaski County. The general surface of the ground in this county is quite flat, a plain slightly inclined to the south, with excellent lateral drainage for the eastern half of the county into the Tippecanoe River, and for the western half into the Monon Creek. Like most of the level, wet regions of the State, this county lies very high, the surface water shedding from its borders in almost every direction.

North of the county, within ten miles, the Kankakee River runs westward to the Illinois line, and several small streams and ditches flow from the north line of the county into English Lake and the lower Kankakee.

The Tippecanoe and Monon flow south through the county as before stated, and close to the west line of the county rises the Pictaminck River, which flows west into the Iroquois.

It is with great difficulty that the position and nature of the stratified rocks underlying the drift in this county can be determined.

There have been few deep bores made, and these tell an inconsistent and unsatisfactory story.

Enough is revealed, however, to show that the drift, which is more than two hundred feet deep along the eastern line of the county, thins out as we go west until the Niagara rocks are barely concealed at Monon, in White County, three miles south of the Pulaski County line, and on a line thence north to Francisville, in Pulaski County. Indeed, at Monon the shallow creek flows upon a floor of Niagara limestone, and the banks are of the same material. In the report of the survey of White County contained in this volume will be found a fuller account of the peculiar and interesting exposure of the Upper Silurian rocks at that place and the lesson to be drawn therefrom. The same Niagara limestone was found at Francesville at a depth of about a dozen feet immediately underlying the shallow cloak of drift. There can be little doubt but that the Silurian rocks have been upheaved along the line dividing Pulaski from Jasper County, but the extent of the upheaval and the direction of greatest energy can not yet be ascertained.

At the town of Winamac, situated fourteen miles in a northeasterly direction from Francisville, the bore made for the citizens' gas well discovered the Devonian shale below one hundred and ——— feet of bowlder drift, and the Devonian rocks were pierced to a depth of —— feet before the Niagara limestone was reached. Whether there is a gradual rise of the Silurian rocks from Winamac to Francisville, or whether the upheaval is more pronounced and confined to narrower limits along the western border of the county, can not yet be certainly known.

The Niagara rock is everywhere out-cropping, or barely concealed by the drift from a point in White Post Township, three miles north of Francisville, to a point three miles south of Monon in White County, and from a point two miles east of Francisville to Renssalaer in Jasper County on the west. The crown of the arch appears to be in a line running northwest and southeast through Monon, passing two miles west of Francisville toward the head-waters of the Pinkaminck River.

In this area all the strata of the sedimentary rocks are upheaved, at least all below, and including the Niagara limestone. Thin patches of Devonian limestone, and possibly small areas of Devonian slate may be found within the bounds given, and if so, these will be found in place, as they were deposited after the upheaval of the older strata. In Salem Township, two and one-half miles south-west of Francisville, a well was bored in 1867 to a depth of nine hundred and sixty (960) feet on what is known as the "Blair farm," which proved to be of the most interesting character. At a depth of nine feet the Niagara limestone was reached, and after passing through this to a depth of probably six-hundred and twenty feet, (though the neighborhood report says five hundred feet) a stratum of gas-bearing rock was found, and a strong flow of gas at once began. The boring was persisted in until the water was struck in the Trenton limestone and the bore was flooded, the water rising to a point far above the gas-bearing rock. The force of the gas lifted the water to the surface and a flowing well was the result. The outflow of water and gas was continuous for nine years, since which time it has been intermittent. The water is clear and not unpleasant to the taste though strongly sulphuretted. It has a neighborhood reputation of being very wholesome and having valuable medical properties. Doubtless its offensive smell has much to do with its supposed medical value. The gas flowing from this well was at once utilized by the farmer near whose residence the bore was made, in cooking feed for his stock and in lighting a large lamp, which was kept burning day and night, the gas being conveyed to the lamp by an iron pipe. The big, bright flame served as a well known beacon for the neighbors in crossing the prairie for many years.

This well was never cased, and of course a process of drowning has been going on for twenty years, and the water has so far destroyed the outflow of gas that the artesian character of the well has ceased, and only a bubbling of the surface water betrays the presence of the escaping gas. Since the discovery of natural gas in Ohio and northeastern Indiana attention has been drawn to this old find of gas, and Mr. Bucklin, of Chicago, has purchased the old "Blair farm," and is thoroughly testing the field. The first bore was made at a point within three hundred feet of the old well, and after going through six feet of drift and six hundred and twenty feet of rock a strong flow of gas was found, and the boring was not further persisted in. The pressure of the gas at once reached two hundred and fifty pounds to the square inch, and this pressure has since been steadily maintained. The quality is excellent, a light, clear and almost odorless gas, burning with a fine, clear flame with very little smoke, while the heating qualities are good, as well attested in the furnaces of the engine which is being used to drill the wells now being bored. With no lack of means at his command, and with enterprise and liberality equal to any occasion, it is safe to say that Mr. Bucklin will fully develop this new gas field, and determine the question as to whether the reservoir is a local and limited one, or whether, contrary to all previous discovery in this State, an enduring supply of natural gas shall be secured stored in the strata above the Trenton rocks. Many questions of great interest to the geologist will call for investigation and settlement if this flow of gas shall prove to be permanent, as it now promises to be.

It will be interesting to discover whether the stratum of porous limestone here found at the base of the Niagara deposit is the original storehouse of the gas, or whether the Trenton limestone, rent and fissured by an old upheaval has yielded its garnered gas to the higher stratum. It may yet be found that the supply of gas stored in this stratum of rock is limited, and will fail after a short use, and in favor of this theory it may be said that the deep bores at Francisville, reaching and deeply penetrating the Trenton rock, found no gas; that one of the wells drilled by Mr. Bucklin on the "Blair farm" only about five hundred (500) feet north of the well "number one," which yields a good flow of gas, was drilled into the Trenton rock until flooded with "Blue-lick" water and yet emitted no gas; and that wells bored to the north, at Medaryville, to the south at Monon, and at other proximate points have yielded no gas.

The shattered condition of the Niagara limestone, which is the surface rock in the region of these wells, indicates that in this locality the ancient upheaval was of a very violent character, and accompanied with much concussion, for the stone is not simply broken, but split and shattered in the most extraordinary manner. The surface rocks at Monon dip in many directions and are crushed together in places in the most confused and chaotic way. That this shattered condition of the Niagara limestone is not superficial, but extends to the lowest stratum, is proved by the action of the drill in every bore yet made at this point. The gentlemen engaged in boring the wells at Francisville, as well as at Monon, make the uniform complaint that the drill in its descent finds cracks in the limestone with such an inclination as to deflect the drill from its course and thus render the boring extremely difficult, and in several instances the crevice was so great that the bit was lost. A few miles northwest of Francisville Mr. J. H. Prewitt, with the assistance of other gentlemen, cleared the earth from about a natural spring to the depth of eight feet, laying bare the Niagara limestone. It was found that the clear cold water rose in great volume from a long crevice in the rock. This crevice has a width of about ten inches, slightly inclined to the southwest, and is evidently of great depth. A long pole thrust down finds no bottom, and the character of the water indicates its subterrane reservoir.

Arrangements have been made by the enterprising citizens of Francisville with Mr. Bucklin, to pipe a supply of gas to that town, and before this report is in type the sooty coal and cumbrous cord-wood which has heretofore served the citizens for fuel will have yielded place to the lighter, cleaner and less troublesome gas. Mr. Bucklin has two wells now flowing about equal quantities of gas, and other bores will be drilled in as rapidly as possible. The work is being done by Mr. Jack Robinson, who has had large experience, having drilled some of the earliest gas wells found in Pennsylvania, and later in the Lima, Ohio, field, and in Eastern Indiana sunk a large number of successful wells. He has great confidence in this new field being developed, that it will prove a permanent as well as plentiful supply of fuel for the neighboring towns to which it may be piped, and that no fears need be entertained as to its exhaustion.

Should this field prove to be as valuable as now indicated, much will be added to the wealth of Pulaski County, and the gas having been piped to the town of Monon, in White County, a distance of only five miles, there can be little doubt that the shops of the Louisville, New Albany & Chicago Railway will be attracted to that place, and the result will necessarily be a rapid and material advancement in wealth and prosperity.

Before the drilling of the wells on the "Blair farm," by Mr. Bucklin, the citizens of Francisville bored two wells in the town, in each of which the Trenton limestone was reached at about nine hundred and five feet. The Niagara limestone was, as usual in this vicinity, found to be the surface rock, and was with the greatest difficulty penetrated on account of the shattered condition of the rock, the oblique fractures leading the drill estray. At a depth of about six hundred and twenty feet the Niagara limestone having been passed through, a porous limestone was entered and a flow of excellent lubricating oil was struck. This yielded at the rate of five to ten barrels per day, and the boring should have been arrested at this point, but the citizens, contrary to the advice of Mr. Robinson who was sinking the well for them, insisted on tapping the Trenton limestone, and this was done. No oil or gas was found in that rock, and the boring continued until the water flooded the well and the oil was drowned.

Traces of bog iron ore are discoverable in many places in this county, but there are no deposits of sufficient importance to merit the attention of manufacturers. There are no valuable mineral deposits yet disclosed anywhere in the county. Should the natural gas prove persistent and plentiful we may expect a considerable advance in the material prosperity of the towns within reach of the newly discovered field. The work of the ditcher will, however, do more for the future prosperity of Pulaski County than any development of the possible stores of oil and gas hidden in her rocks. Much has already been done in this direction in the construction of large open ditches, but the net-work of under drains required to render the soil thoroughly cultivatable, is only fairly begun. Enough has been done to greatly improve the sanitary condition of the county, as well as to lay the foundation of effective husbandry, and nowhere is the immediate effect more apparent than in these heavy soils.

There are few historical notes of great interest connected with this county. All that region of country comprised within lines drawn from Detroit, Michigan, to the southern point of Lake Michigan, thence to the mouth of the Wabash River, thence to the mouth of the Scioto River, thence to Detroit, was once the dominion of the Twigtwees or Miami Indians. As early as 1672 the French missionaries and traders found them in possession of this domain, and they held it against all intruders until the advent of the all-conquering race. The region adjacent to the north bend of the Tippecanoe river was the last place abandoned by these Indians, and it was only in the year 1832, by a treaty signed by Wah-she-o-nos, Wah-ban-she, Aub-bee-naub-bee, and other chiefs on the 26th day of October, that what is now Pulaski County was ceded to the United States. Even after this treaty the Indians did not all leave for their new homes west of the Mississippi River until the year 1842.

Neither these Indians nor the earlier mound-builders have left many marks of their long occupancy of the country.

In Indian Creek Township, at a point opposite Pulaski Mills, in the "bottom" or alluvium of the Tippecanoe River, is a large mound about one hundred feet in diameter at the base, and which was, before being plowed over, fully twelve feet high. Many years ago an excavation was made in this mound by a minister then sojourning in the neighborhood, with the result of unearthing several crumbling human skeletons. The bones were reported to have been very large and strong, but soon yielded to the action of the air and crumbled to dust.

At two points in the river valley south of Pulaski mills other smaller mounds are found. These have been opened, the result being a few crumbling bones mixed with charcoal. No implements were found, though many arrow and spear heads, stone axes, and similar weapons of war and the chase have been picked up in different parts of the county, notably in the alluvial valley of the Tippecanoe River.

THE TIPPECANOE RIVER.

This stream is a natural feature of the landscape of several counties of such exceeding beauty and value as to deserve a separate paper devoted to it exclusively, but the limits of this report deny it, and attention can only be called to that portion of the stream within and near the borders of the counties of Pulaski and White. With an average width of one hundred feet, the beautiful river enters Pulaski County from the east at a point about half way between the village of Marshland, on the Vandalia Railway in Fulton County, and the town of Monterey, in Pulaski County. For five miles from thence in a northwesterly direction it flows through the northeast corner of Pulaski County, crossing the north line of the county into Starke County, where at a point called "North Bend," at the farm house of Mr. J. Stryker, it boldly turns to the south under a high bank, and thereafter maintains a generally southerly course until it empties into the Wabash near Lafayette.

I have called it a "beautiful" stream, but neither that word nor any other is strong enough to properly characterize its exceeding loveliness.

There are many fine streams in the State of Indiana, but not one that can be compared with this river. Its rare beauty, its splendid fishing, the good shooting to be found along its banks, the numberless cold springs that bubble out of the high bluffs, the small green islands that are met at almost every turn of the stream, the clear water flowing over the assorted sand and bowlders of the northern drift, or the masses of heavy green grass attached to the bottom and waving in the moving water like a tiny forest in a "broad and equal blowing wind," lend a charm against which few hearts are proof. In order to fully explore this fine river I launched a small canvas boat at Marshland, in Fulton County, and floated down the stream a distance of fifty miles to Monticello, in White County. Such a trip, without any companion, would, under ordinary circumstances, prove to be a very lonely one, but such is the varying beauty and interesting character of the rapidly flowing river that no journey ever proved more pleasant. From Marshland to a point south of Pulaski Mills, in the southern part of Pulaski County, the river flows in a bed of bowlder clay, at no point cutting through the drift, but at a point two miles north of the line of White County the channel of the stream is cut down to the Devonian shale, and from thence down the stream to its confluence with the Wabash the strata of the Devonian rocks outcrop at many points, notably near Norway Mills, in White County, and at a bluff south of Monticello.

At the time of my voyage the stage of water in the river was extremely low, and every characteristic of the river bed was easily discoverable. Flowing, as it does throughout most of its course, in a channel hollowed in the bowlder drift, the stream is a succession of pools and shallows, neither of great extent, and alternating with such ever varying form and character as to form a source of pleasure always enhanced by the element of surprise. By the sorting process of the water the large bowlders have been selected from the drift and, by reason of their greater weight, deposited in the bed of the stream. In times of flood the increased power of the water has pushed them along until some point of obstruction has been reached, where a vast accumulation has taken place, and these, damming the water above, form a long and deep pool.

The water from the pool over-lipping the dam and struggling through the long tangle of bowlders below forms a ripple, shallow and swift, in which the fish find favorite nesting grounds.

There is no mill nor any artificial obstruction of the stream from the crossing of the Vandalia Railway at Marshland to the town of Winnamac, a distance of nearly thirty-five miles following the sinuosities of the river, and nowhere in the State is there such a reach of running water so well stocked with fine fish. It is not only as an angler's paradise, however, that this river has precedence of our many streams, but the sportsman who loves the gun better than the rod will find the banks of the Tippecanoe the best game preserves yet remaining in the State. The prairies which are skirted by the river in Pulaski County are yet favorite feeding grounds of the pinnated grouse, and the best wood-cock cripples to be found in the Mississippi Valley, borders Mill Creek near its junction with the Tippecanoe three miles South of Winnamac. Not only at this one point, but everywhere along the river in damp bottoms, in springy places under bluffs, and wherever secluded feeding grounds appear, the wood cock may be found.

Formerly the waterfowl in great abundance visited the stream in the spring and fall of the year, but now the flights are irregular and the numbers annually decrease.

The small-mouthed bass (*Micropteros Dolinuiu*) is the principal game fish inhabiting these clear waters, though the large-mouthed bass (*Micropterous Salmoides*) may occasionally be found, and the pike or pickerel, which formerly reigned in undisputed mastery, both because of its prowess and numerical superiority, may yet be found, though in greatly lessened numbers. Though the angler may lament the steadily decreasing numbers of the pike while remembering his game qualities, yet the loss by the extinction of this voracious fish will be more than compensated by the gain in other game varieties, for the pike is the remorseless and insatiable enemy of all the other game fish, and will not hesitate to make a meal off his own kind.

A few years ago the use of seines and dynamite threatened to render the Tippecanoe River as barren of game fish as the same shameless violations of the law have left many of our other streams, but better views seem now to obtain, and the seining has ceased, and only an occasional instance of the use of explosives and of fish poisoning occur. The value of the river to the people of the State as a preserve of the most valuable game fish can scarcely be over-estimated, for if nowhere else in the State may we look for such a supply of the dainty food yielded by *Micropteros Dolinuiu.* That something is gained by preserving the game fish in our rivers for the mere pleasure of angling, does not admit of a doubt, but when a valuable source of food supply is added to the delights of the rod and reel, the economist should make common cause with the sportsman in the work of protection. The statutes which have been framed to guard our streams against the seine, poison and dynamite, are sufficiently stringent, but as detection of offenders is not easy because their depredations with the seine are generally at night, and with dynamite in secluded places, and as no inducement is given to informers, the criminals go unpunished. The law should be so amended as to increase the penalty in case of conviction and one half the penalty should go to the informer. In such case the detection of the ravages would be certainly accomplished, and the game fish given the same opportunity to breed and increase which we allow to the ruffed and pinnated grouse of our woods and prairies. When this is done the angler may seek the deep pools of the Tippecanoe River at any time with full confidence in a good day's sport with the result of a well-filled creel

The geological notes collected while exploring this stream are included mostly in the report upon White County and in the paper upon the Wabash arch. There are fine outcroppings of stratified rock, mostly Devonian shales and limestone (Corniferous), at points from a little above Monticello to near Lafayette. These outcroppings show the deposits above the Niagara in place, while the latter, and all inferior deposits, are greatly disturbed. Indeed, the channel of the stream has been controled for a considerable part of its length by a great break in the stratified rocks, as is also the case with the Wabash River. Where the Devonian formation is the surface rock we find that the glacial plow has laid the furrow for the stream, and this is no doubt true to a degree where the Niagara comes up; but the larger fact remains that a peculiar broken and creviced condition of the Upper Silurian strata has greatly affected the course of the stream wherever the Devonian has been displaced by erosion.

The bottom lands of the Tippecanoe River are justly famed for their extreme fertility. The soil is a warm, sandy alluvium, rich in vegetable matter, easily cultivated and wonderfully productive. Some extensive and flourishing mills are situated on this river near and below Monticello. The power furnished is ample, and comparatively inexpensive.

The farther southward and westward we follow the course of the river, higher and bolder become its bluffs and the deeper sinks the channel. In many places fine sections of the drift have been made by the cutting of the stream. Usually, however, bluff alternates with bottom, so that on one side of the river the banks may be high and precipitously steep, while on the other lies a wide, low stretch of fine alluvial farmland.

In some places the timber, which consists of oak, hickory, walnut, maple, ash, plane and poplar (tulip—*liriodendron tulipifera*) is very heavy, but in the main it is scattering and has been greatly reduced by indiscriminate cutting.

Upon the whole, the valley of the Tippecanoe is a well drained, fertile, healthful, highly cultivated region, owned and held by a happy, intelligent and very prosperous people.

PRELIMINARY SKETCH OF THE CHARACTERISTIC PLANTS OF THE KANKAKEE REGION.

The following lists will be of use and interest to those who (not technical botanists themselves) are lovers of plants and like to identify them when found; they will also have value for the professional botanist in that they afford a record, so far as they go, of plants actually found, with a description of the spots upon which they grew. A report like this, made for the people, is utterly without use or interest to nine-tenths of its readers (or rather to nine-tenths of those who ought to be its readers) when it is purely technical. Our great American master of botany, the lamented and venerated Asa Gray, knew well the effect of popularizing science and it is to him that we owe our very heaviest debt of gratitude for many long and vigorous steps in the right direction.

It is often the case that a student, struggling (in the early days of his field-studies) with the difficulties surrounding the identification of species, would be greatly helped if he had in hand a localized catalogue which would give him the common name of each plant characteristic of the locality together with a popularized though sufficiently technical description. Indeed I do not regard him a safe botanist, no matter how famous, no matter how great his experience, who is not willing to be taught through the medium of the simplest and least technical language when need be. Text books and the volumes meant for the shelves of scientists only may be best written in the language of science; but I hold that no book or communication aimed at the popular understanding should be made a puzzle rather than an elucidation.

The following is but a beginning, and is meant as the merest sketch containing a few of the plants most characteristic of the region drained by the Kankakee River. We hope to make the lists very full and valuable in the next report, as we have our work fairly begun and the methods of observation pretty well perfected.

1. ARABIS LYRATA, (*cress, or rock-cress.*) Very slight plant with delicate leaves starting up from the root and shaped like a lyre. Flowers brilliant white. This was found in light, sandy soil, not far from the shore of English Lake.

2. ARENARIA STRICTA, (*sandwort.*) A small plant with thickly set bristle-like leaves crowding its stem. Terminal flowers with open cyme, sharp sepals and conspicuous white petals. On high barrens near Francisville.

3. ARTEMISIA CANDATA, (*wormwood.*) A tall weed having divided pinnate leaves with fine thread-like capillary divisions. Head loosely panicled. Sandy soils of the lake shores.

4. ARETHUSA BULBOSA, (*no common name.*) This singularly beautiful little plant sends up a scape or smooth stem from its root bulb, which bears a brilliant rose pink flower. Found in the marshes of Starke County.

5. ASTER LONGIFOLIUS, (*Long-leaved Aster*) Tall weed with bluish purple flower, long, tapering, pointed glassy leaves. Plentiful in the wet, sandy soils of the Kankakee bottoms.

6. ALLIUM CERNUUM, (*Wild Onion.*) This curious plant sends up a long, angular scape from the ground. Flowers rose-color. Leaves grass-like, keeled on the bottom. Damp shores of lake.

7. BETULA PAPYRACEA, (*Paper Birch.*) This is reported on the Kankakee, but I have not seen it. It is the well-known tree from which the Indians procured bark for building canoes.

8. BETULA PUMILA, (*no common name.*) Reported. I have not found it, and doubt its existence in this region, though good authority stands against me.

9. CARDEMINE RHOMBOIDEA, (*Cuckoo-flower, Bitter-cress.*) This pretty plant I found in the wet semi-marshes and spouty, arenaceous soils in Pulaski County. It bears on a straight stem a large purplish flower. Leaves toothed and oblong, the lower one heart-shaped.

10. CICUTA BULBIFERA, (*Cowbane.*) Reported, but not seen. It should be found in the barrens, probably.

11. CORISPERMUM HYSSOPIFOLIUM. Reported, but I have not seen it in the immediate region of the Kankakee.

12 DROSERA ROTUNDIFOLIA, (*Sundew.*) Not often seen, but when sought will be easily found in the boggy spots in the Kankakee Valley. White, round leaves on long petioles forming a tuft, waxy or sticky, white. This is the insect-catching sundew.

13. ELODEA COMPANULATA. Reported but not seen in the immediate vicinity of the Kankakee.

14. Epilobium palustre, (*no common name.*) Plentiful in the wet bottoms and along the river's low shores. Purplish flowers, leaves lance shaped, linear. Plant slender and delicately hoary.

15. Lathyrus maritimus, (*Beach Pea.*) Found in Starke County on sandy hill-side near Cedar Lake. Peduncle with purplish flowers, stipules large, leaflets crowded, oval.

16. Larix Americana, (*Hackmatack.*) Reported in some of the upper swamps of the Kankakee. I have not seen it there, but have the report from excellent authority.

17. Lechea major, (*Large Pinweed.*) Tall hairy stem, roundish leaves with short points, purplish closely packed flowers, sandy hillsides of Starke County.

18. Lilium superbum, (*Turk's Cap.*) This beautiful little plant is not common in the Kankakee region, but I have found it in the wet meadows of White County. Flowers yellow, darkly spotted, set in thick pyramid. Leaves lance-shaped and whorled, or scattered.

19. Linum sulcatum, (*Wild Flax.*) Reported, but not seen growing in the immediate region of the Kankakee.

20. Linnæa borealis, (*Twin Flower.*) A single plant found in Jasper County on the margin of a spouty spring-bog. Creeping stem, hairy leaves of round oval shape, purplish, hairy, sweet-scented flowers.

21. Lobelia Kalmii, (*Indian Tobacco* [?].) Found on sandy bank of the Kankakee. About a foot tall, root leaves blunt or obovate, stem leaves scattered, lance-shaped. Flowers brilliant blue

22. Menyanthes trifoliata, (*Buckbean*). Scape ten inches long, with a white-pink flower Found in a boggy spot on north side of Kankakee, below English Lake.

23. Myriophyllum spicatum, (*Millfoil*). Leaves above water rounded and blunt, bract-like. Flower insignificant. Found in shallow lagoons.

24. Oxalis Autosella, (*Wood sorrel*). Common enough on sandy, rather dry, banks and sand ridges. Pink veined flowers, much like common sorrel.

25. Potentilla fructicosa, (*shrubby cinquefoil*). A silky, bushy, cinquefoil growing on the barrens. Noted in Starke and White counties on wet spots between sand ridges.

26. Potentilla argentea, (*silver cinquefoil*). Growing on the dryest parts of the sand ridges in Pulaski County. A groveling, woolly weed, thickly branched, having peculiar pinnately cleft leaves woolly white below.

27. Ruellia ciliosa, (*no common name*). Reported on the dry sand ridges, but not seen in the immediate valley of the Kankakee.

28. Silphium integrifolium, (*Rosin plant* (?)). Found on the prairie near San Pierre. Leaves oval lance shaped or heart shaped, distinct.

29. Scutellaria galericulata, (*Skull-cap*). A slender stemmed, smooth plant, with heart-shaped or rounded lanceolate, acute, serrate leaves. Blueish flower with strongly arched upper lip.

30. Solidago Missouriensis, (*Golden Rod*). Reported, but not seen in the Kankakee valley proper.

31. Silphium laciniatum, (*Compass plant*). Root leaves rough, bristly, deeply cleft, pinnatifid, and thought by some observers to prefer a north and south line for their edges. Prairies bordering the river.

The foregoing thirty-one species, should they prove resident, may be taken as strictly characteristic of the three divisions of the Kankakee region, to-wit: The lake region, the prairie region and the barrens region, speaking with reference to Professor Coulter's lists and to his able paper contained in the report of this department for 1885–6. But the area immediately bordering the Kankakee River shows a number of plants common to the south, and which are not strictly or peculiarly characteristic of any of the divisions above mentioned. These are aquatic and semi-aquatic species imported, no doubt by migratory birds. The *Nelumbium duteum*, water chinquepin, would appear to have come from the south, along the course of the migratory water fowls. So *Nuphar sagitifolia*, or arrow-leaved spatter-dock, observed in a lagoon of the Kankakee, near English Lake, must have found its way, in the same manner, from the Mississippi region. *Ambrosia bidentata*, prairie ragweed, is found on the banks of the Kankakee, where there is no prairie proper. *Asclepias rubra* was found on the sand hills of Starke County, and *A. phytolaccoides* was noted near the same spot. These are milk weeds, the first common from New Jersey south, and the second a hill country plant not to be expected in this region. Two species of Lady's slippers have been identified.

Cypripedium acaule. This beautiful plant was found in a wash or ravine of a sand ridge in Starke County, and *C. spectabile* was noted in the woods bordering the Kankakee River not far below the crossing of the L., N. A. & C. Railroad.

Cypripedium arietinum is reported as existing in the boggy woods of the valley, but I have not yet seen it there. It usually is about 8 inches high, slender with lance-shaped oblong leaves and a dull purple, insignificant flower having a conical sac, one ovate or lance-ovate sepal and two linear. Petals two, linear. *Aplectrum hyemale*, common name Adam and

Eve, was found in a "second bottom" between the river and the sand-hills, a single specimen noted, in Starke County. *Viola delphinifolia*, larkspur leaved violet, and *V. rotundifolia*, round-leaved violet, were found almost side by side in the barrens of the northern part of Jasper County. *Passiflora lutea* was noted in White County. This species of passion flower, apparently the degenerate relative of the magnificent southern species (*P. incarnata*), is a slender, timid vine with entire blunt lobes of its leaves scarcely distinguishable at a little distance from the yellowish green flowers. *Lysimachia quadrifolia* was shown me as having been found in the southern part of Porter County, but I have not seen it in the Kankakee region. *Agrimonia parviflora* was reported; probably a mistake. *Vaccinium vacillans*, huckleberry. This species was seen in the sand-hills near English Lake. It may be identified by the yellowish color of its twigs and by its smooth oval, glaucus leaves which are entire. It is sometimes called winter huckleberry. *Humulus lupulus*, common hop, was found in the thickets bordering the Kankakee and along the margins of the "second bottoms." *Hypericum ellipticum*, one of the species of St. John's wort, is found in the wet open woods of the lowest Kankakee bottom lands. Its oblong spreading leaves are thin and its flower paler than the other species and set in a nearly naked cyme. Much smaller than *H. aureum* of the south, and not to be mistaken for *H. sphærœarpon*, which is larger and has its leaves oblong-linear, diverging and obtuse, and its pods globular. This last is reported from the banks of Monon Creek, but the observer was probably mistaken. The St. John's worts are not very common anywhere north of the Ohio River in the west. Of *Helianthus* (sunflower) there are a number of species. I noted *H. occidentalis*, *H. mollis*, *H. strumosus* and *H. rigidus* (?). The last named is doubtful. *Palygonum hydropiper* (water pepper) was noted, and a few specimens of *Rumex orbiculatus* were observed near the Kankakee below English Lake. *Impatiens pallida* and *Impatiens fulva* both were found in wettish spots between the ridges. These are commonly called touch-me-not, on account of the spiteful action of the seed-pods when shaken or touched. They are generally known as balsam. Flowers panicled, yellow with reddish brown freckles, sac tapering into a long, soft spur. Stems and branchlets are semi-transparent, succulent, brittle; leaves alternate oval, delicate. The two species are much alike; but the flower of *pallida* is, as the name indicates, paler than that of *fulva*, which is a brilliant orange. One small bush of *Negundo accroides*, box-elder, was observed in a thicket below the L., N. A. & C. R. R. crossing. *Guaphalium polycephalum* and *G. decurrens*, the two cud-weeds, or life-everlastings, were not plentiful, but found here and there on the dryest parts of the barrens. *Autennaria margaritæ*, *pearly-everlasting*, grows on sand-knobs and dry barrens ridges, 18 inches high continuously leafy from the ground up; leaves lance-shaped, linear; the head in a broad corymb with scattering imperfect staminate flowers, the whole showing a pearly whitish gleam. *Vernonia fasciculata* (*iron-weed*) common in the somewhat sandy spots of the prairies. *Callirrhœ triangulata* (*mallow*), a single plant noted in Starke County on the bank of Yellow River. It may be common on the dryer parts of the light prairies. *Fragaria Virginiana, var. Illinœnsis* (wild strawberry) common on the dry barrens knobs and sandy slopes. *Mitchella repens* (partridge berry) was noted on the tops of barrens ridges in the oak woods of Starke County near Cedar Lake. *Galium lanceolatum* is reported from Porter County, but I have not seen it. It is a species of wild liquorice. *Dioda teres* (button weed) is noted as having been seen on the sand-hills, but the locality is not kept. This is a southern plant, common in sandy old fields in the Atlantic coast States from New Jersey southward. *Valeriana edulis* (valerian root). Indian root, one specimen identified growing in Kankakee bottom near English Lake, a singular and rather rare plant with heavy root-leaves spatulate; stem leaves divided in 3 or 7 long narrow divisions with delicately woolly edges. The root is a curious radish-shaped, edible turnip which was much sought after by the Indians.

Houstonia minima, bluet, a few seen on dry barren ridges in the thin woods of Starke County north of Cedar Lake. The rushes of the Kankakee will be interesting, likewise the mosses, grasses and ferns, when they shall have been studied and reported, more especially as regards the light they will throw upon the question of the survival of species far outside of their proper habitat. The timber trees and larger arborescent plants of the Kankakee region have no points of great interest botanically speaking. *Liquidambar Styraciflua*, sweet gum, has been reported, but I have not verified this and doubt its existence in the Kankakee bottoms, though it is possible, as the tree is found in New England and in Southern Illinois, Southern Indiana, and in Missouri. In a general way the trees of the Kankakee swamps are common to all the swamps of Northern Indiana and Southern Michigan.

Of the ash trees (*Fraxinus*) the *F. Americana*, white ash, (reported but not seen by me), the *F. sambucifolia*, black ash, and *F. vividis*, green ash are probably present. The maples are chiefly *Acer rubrum*, swamp maple, *A. saccharinum*, sugar maple, and *A. dasycarpum*, white maple, with, probably, varieties of each species, especially of the sugar maple. Of the walnut family, which includes the hickories as well as the walnuts, the list will contain *Juglans nigra*, black walnut, and *J. cinerea*, butternut, both rare in the valley, *Carya sulcata*, shell-bark hickory, *C. porcina*, pig-nut hickory, and *C. amara*, bitternut hickory. Of the oaks nearly or quite all the species common to middle Indiana are found. *Quercus nigra*, black-jack, probably; *Q. ilicifolio*, scrub-oak, and *Q. palustris*, Spanish or pin-oak, and the large timber trees white-oak (*Q. bicolor*), bur-oak (*Q. macrocarpa*) and probably *Q. rubra*, red-oak of stunted growth, are plentiful in places. The bass-wood (*Tilia Americana*) was noted along the dryer banks of the Kankakee, but the trees were not large. The beech (*Fagus ferruginea*) is not common, but by no means rare along the higher bottom-lands of the river. Some stunted hackberry (*Celtis occidentalis*) trees were observed in the second bottom of the Yellow River near the Kankakee. The poplar, yellow-wood, or tulip-tree (*Liriodendron tulipifera*) is not common, though an occasional one may be seen along the Kankakee and Yellow River. The cotton-wood (*Populus monilifera*) is met with unfrequently. The wild cherry tree (*prunus serotina*) is seen growing small here and there in favorable spots along the second bottoms. A few red-bud or Judas-trees (*Cercis Canadensis*) grow in the thickets on the richer highlands of the Kankakee, but the plant is out of place, as its true habitat is much farther south. The coffee-nut tree, (*Gymnocladus Canadensis*) was seen along the timber-line of the Kankakee, especially on the south side of the river. The hornbeam or water beech (*Carpinus Americana*) not very common along the Kankakee and tributaries, overhangs the banks, however, here and there. Of the hazel-nut (*Corylus*) both species, *C. Americana* and *C. rostrata*, reported, but I saw neither. The service-berry, or June-berry (*Amelanchier*) is also reported, but without any description as to variety. I did not find it. So a hawthorn (*Crategus*), probably *C. tomentosa, Var. mallis*, was seen but not examined, as I was in a canoe and, although near shore, could not land. The wild apple (*Pyrus*), *P. Angustifolio*, narrow-leaved crab apple, and the choke-berry (*P. arbutifolia*) probably are present in the second bottoms, but I can say only that they are reported, as I have not identified them.

This closes the list, so far as the work has gone, and it is proper to say here that the botanical examinations have been merely incidental to the work of the survey, the notes having been hurriedly taken—on the run, so to say—while in search of geological facts. It is to be hoped that the future will afford the opportunity of making out a complete and properly arranged list of the plants of this great untouched region.

PRELIMINARY SKETCH OF THE AQUATIC AND SHORE BIRDS OF THE KANKAKEE REGION.

Beginning with the plovers and ending with the ducks, the following list includes all the birds commonly alluded to as aquatic and shore birds so far reported to me from the Kankakee Valley, or identified by me in that region. It is by no means a complete list, and scientific arrangement is not attempted, the field notes being given with very slight revision simply with a view to their preservation so that they may be used in a future complete report on the natural history of the Kankakee region. A systematic catalogue ought not to be thought of in connection with incomplete notes, but a simple field sketch will be of interest in many ways to all who are students of nature, and it will serve to attract attention to a region singularly rich in material for the note-books of such students.

The field plover, or bull head (*Charadrius dominicus*), common on wet meadows near the Kankakee in spring and autumn. A great table delicacy and much sought after for the market by "pot-hunters."

Kildeer plover (*Ægialites vociferus*), plentifully distributed over all the open dryer spaces.

Wilson's plover (*Æ. Wilsonius*), one specimen killed some years ago. Not very common near the Kankakee.

Ring-necked plover (*Æ. semipalmatus*), rather common at one time, it is reported, but not so now.

Wilson's phalarope (*Steganopus Wilsoni*), seen on the marshes, and killed in the autumn.

The woodcock (*Philohela minor*), the most precious of all our game birds, is met with in the open bogs and boggy woods all along the Kankakee and its tributaries. It is often called big snipe and bogsucker.

Jack-snipe, or Wilson snipe (*Gallinago Wilsoni*), is very common in spring and autumn, affording fine sport in the latter season, and much shot in the former. Wet meadows and prairie bogs.

Stilt, sandpiper (*Micrapolama himantopus*), not common, occasionally seen some years ago.

Stint, or least sandpiper (*Actrodomas bairdi*), is seen in compact flocks on the wet meadows in spring and autumn.

Grass snipe, or little jack-snipe (*A. maculata*), drops in, it is said, but I have not identified it.

American dunlin (*Pelidna Americana*), one specimen killed in spring out of a considerable flock.

Ruddy plover, sanderling (*Calidris arenari*), seen on English lake. Not common. Probably quite rare.

Godwit, or marlin (*Limosa fœda*), one specimen killed a few years ago, one seen in 1887.

Green sandpiper (*Ryacophilus solitarious*). One bird killed years ago. Reported as seen occasionally during migration.

Grass plover, or prairie pigeon (*Bartramia longicauda*), not common; rare, perhaps, but seen in mid-summer 1885.

The white ibi's (*Endocimus albus*) is reported. I have not found it.

Great blue heron (*Ardea herodias*), found everywhere along the Kankakee and its tributaries in summer and autumn. It is especially numerous on the marginal marshes of English Lake.

White heron (*Herodias egretta*), one bird seen on English Lake.

Snowy heron (*Garzetta candidissima*), quite common on small ponds and lagoons of the whole Kankakee region in summer.

Little blue heron (*Florida cœrulea*), not common, but often seen on marshes.

Green heron (*Butorides virescens*), common on all the waters.

Night heron or squawk (*Nyctiardia grisea-naevia*), often seen.

Bittern, Indian hen, or thunder-pumper (*Botanrus mugitans*), common, seen everywhere in the grassy bogs and marshes.

Dwarf bittern, least bittern (*Ardetta exilis*), common. Often mistaken for green bittern.

Whooping crane (*Grus Americana*), one or two seen, but quite uncommon.

Sandhill crane (*Grus pratensis*), not seen, though reported.

Virginia rail (*Rallus Virginianus*), one bird killed, not common.

Marsh hen (*R. elegans*), scarce. A few seen during the spring of 1875. One noted as this bird, October 1886, but not taken.

Ortolan, or crake (*Porzana Carolina*), rather frequently seen, possibly it breeds here.

Yellow crake (*P. noveboracensis*), occasionally seen.

Gallinule (*Gallinula galeata*), not common, but is occasionally killed. Can scarcely be called rare here.

Coot (*Fulica Americana*), found in the worst marshes where the grass and weeds are very thick and tall in a slush of water and bog-mud. It is sometimes called crow-duck, more often mud-hen.

Kingfisher (*Ceryle alcyon*), rather common on the Kankakee, numerous on the tributaries.

(I insert here the marsh blackbird (*Agelæus phoenicens*), because it is the bird oftenest seen in all the grassy marshes of the whole Kankakee region. It swarms everywhere.)

The whistling swan (*Cygnus Columbianus*), was seen, but no bird taken.

Wild goose (*Anser albifrons gambeli*), one bird killed in 1876, frequently seen in spring.

Common wild goose (*Bernicla canadensis*), quite numerous in spring and fall, large flocks settling down for a week or ten days.

White brant (*Chen hyperboreus*) is seen in considerable flocks flying over, but rarely alighting.

Mallard, or green-head (*Anas Boscas*), common on the Kankakee and adjacent waters in spring and autumn. Large flocks.

Pin-tail duck (*Dofila acuta*), often seen on river.

Wigeon, or bald-pate (*Mareca Americana*), not common, but occasionally seen.

Teal (*Querquedula*), both green-winged, *Q. crecca*, and blue-winged, *Q. discors*, rather common from spring to late autumn. They breed in grassy, wet tussocks.

Shoveler duck (*Spadtula clypeata*), frequently seen on the Kankakee.

Wood duck (*Aix sponsa*), very plentiful on the Kankakee and its tributaries.

Scaup duck (*Fulix affinis* and *F. collaris*), both species rather common in spring and autumn A few appear to breed here.

Whistler, or golden-eye (*Clangula glaucium*), not common, but noted frequently.

Buffle-head, or butter-ball (*C. albeola*), is quite numerous in spring and autumn. A showy duck, but not first-rate for the table.

Hooded merganser (*Mergus cucullatus*), rather scarce; but seen frequently.

Diedapper, or dipper (*Podilymbus podicipes*), very common.

The eared grebe (*Podicipes* [*auritus*] *californicus*), seen on the Kankakee only once. Probably rare.

GEOLOGY OF MIAMI COUNTY.

BY S. S. GORBY.

Miami County, situated in north-central Indiana, is bounded on the north by Fulton and Wabash counties, on the east by Wabash and Grant, on the south by Howard and on the west by Carroll and Cass. It contains an area of 384 square miles, or 245,760 acres. The county is in the form of a parallelogram, being thirty miles in length, from north to south, and twelve miles wide, with one township forming an L-like projection on the east side, at the southeast corner. The following are the fourteen civil townships in the county: Allen, Perry, Union, Richland, Jefferson, Peru and Erie, on the north side of the Wabash River, and Pipe Creek, Washington, Butler, Deer Creek, Clay, Harrison and Jackson, on the south side of the river. The river runs in a westerly direction, dividing the county into two nearly equal parts.

Peru, the county seat of Miami County, is a thriving commercial and manufacturing city, situated in the central part of the county, upon the north side of the Wabash River, and in the midst of an agricultural region of unsurpassed fertility. The population of Peru in 1880 was 5,280; it is now estimated at fully 8,000. The following towns and villages are located in the northern part of the county: Wagoner, Lincoln and Birmingham, in Allen Township; Gilead and Stockdale, in Perry Township; Mexico, in Jefferson Township, and Denver, Chili and Pawpaw, in Richland Township. South of the Wabash River are Miami, in Deer Creek Township; Waupecong and McGrawsville, in Clay Township; North Grove, in Harrison Township; Amboy and Xenia, in Jackson Township; Bunker Hill, in Pipe Creek Township; South Peru, in Washington Township, and Peoria and Santa Fe, in Butler Township.

The distance from Peru to Amboy is	15 miles.
The distancs from Peru to Bunker Hill is	8 "
The distance from Peru to Chili is	8 "
The distance from Peru to Deedsville is	13 "
The distance from Peru to Denver is	8 "
The distance from Peru to Gilead is	16 "
The distance from Peru to Lincoln is	16 "
The distance from Peru to Mexico is	6 "

The distance from Peru to Miami is	12	miles
The distance from Peru to North Grove is	13	"
The distance from Peru to Paw-paw is	11	"
The distance from Peru to Peoria is	9	"
The distance from Peru to Perrysburg is	11	"
The distance from Peru to Santa Fe is	9	"
The distance from Peru to Stockdale is	15	"
The distance from Peru to Waupecong is	13	"

RAILROADS.

The railroad facilities of the county are most excellent, there being but two out of the fourteen townships in the county that are not crossed by railroads. The Pittsburg, Chicago & St. Louis Railroad (the Pan-Handle) runs northwesterly across the southern part of the county; the Wabash, St. Louis & Pacific Railroad crosses the central part of the county from east to west, following the course of the Wabash River; the Lake Erie & Western, formerly I., P. & C. Railroad, runs a northerly and southerly direction through the central part of the county; and the Eel River Railroad, which follows the course of Eel River southwesterly, through the northern part of the county. The railroads throughout the county are most conveniently and happily located for the agricultural and commercial interests of the country.

SCHOOLS.

The total population of the county is near 30,000, and the school population a little less than 10,000. The total number of pupils attending school in 1886 was 6,244, and the average attendance was 4,412. The school terms throughout the county averaged 121 days in length—a period equal to a fraction more than six months. The teachers of the county have endeavored to raise their schools to the highest standard of excellence, and by a system of institutes and teachers' associations they have been able to keep in the van of progress. The schools are most efficiently managed, the principal object being to assist in the development of the minds of the youth, that they may acquire, without cramming, a knowledge of those branches best calculated to assist in the business of life, and to develop strength and integrity of character. The total value of all school property in the county is about $150,000, and the total tuition revenue about $75,000.

CHURCHES.

There are about thirty-five church organizations and the same number of church buildings in the county, representing Baptists, Catholics, Episcopalians, Friends, Disciples of Christ, Lutheran, Congregational, Methodist, Presbyterian and United Brethren. The church membership numbers about 6,000, and the value of church property is about $100,000. The average Sunday-school attendance is about 3,000.

Any locality that provides good schools and patronizes them liberally, that erects good church buildings and contains a church-going population, is always a desirable locality to live in. A locality of churches and good schools is a locality of sobriety, intelligence, industry and honesty—just such a locality as the intelligent, enterprising farmer, mechanic, lawyer, doctor or other man of intelligence will seek when hunting a new location. Any part of Miami County furnishes just such a locality.

AGRICULTURE.

Miami County is primarily an agricultural county. The county is generally level, with sufficient undulations, produced by the erosions of the streams, to give good natural drainage to a large portion of its area, which has been supplemented in the flat portions by surface ditches and underground tiles. The soils consist of sand or clay loams, and are of great fertility. The yield of wheat in 1886 from 41,988 acres was 777,107 bushels, an average of over $18\frac{1}{2}$ bushels per acre; 42,258 acres of corn yielded 1,643,526 bushels, an average of nearly 39 bushels per acre; 6,081 acres of oats yielded 219,721 bushels, an average of more than 36 bushels per acre; 140 acres of barley yielded 3,342 bushels, an average of about 24 bushels per acre; 42 acres of buckwheat yielded 534 bushels, an average of about 13 bushels per acre; 120 acres of rye yielded 1,953 bushels, an average of over 16 bushels per acre; 633 acres of flax yielded 6,292 bushels of seed, an average of about 10 bushels per acre; 9,647 acres of timothy yielded 17,637 tons of hay, an average of $1\frac{4}{5}$ tons per acre; 22,321 acres of clover produced 33,304 tons of hay, an average of $1\frac{1}{2}$ tons per acre, besides 2,443 bushels of seed valued at $10,000; 932 acres of Irish potatoes yielded 70,219 bushels, an average of 75 bushels per acre; and 26 acres of sweet potatoes yielded 1,550 bushels, an average of 60 bushels per acre. These statistics of products during a year of average crops, in a general way illustrate the fertility of the soil. Improved methods of husbandry, with a gradual increase in the area artificially drained, are materially augmenting the average of the crops. There were 404,383 rods—nearly 1,300 miles—of drain tiles in use in the county in 1886.

The soils of the county are generally a loose, black, sandy or gravelly loam, except in the flatter portions of the southern part of the county, where there is, as a rule, a considerable proportion of clay. There is but very little necessarily waste land in the county.

TIMBER.

Miami County was originally heavily timbered. The vast forests contained immense amounts of the finest walnut, poplar, oak, ash, hickory and other varieties of timber. The supply of walnut and poplar has been almost wholly exhausted in recent years, though there yet remains in the wood lands a fair proportion of oak, ash, hickory, beech, elm and maple timber. There are yet remaining in .the county about 55,000 acres of timber, or wood land, a considerable proportion of which has been largely culled. The following is nearly a complete list of the trees and shrubs indigenous to Miami County, although there are many other species and varieties of trees, shrubs and vines, now growing wild in the county, that have escaped from cultivation:

Acer dasycarpum, white maple.
Acer rubrum, swamp maple.
Acer saccharinum, sugar maple.

Aesculus glabra, buckeye.

Almus serrulata, water alder.

Ampelopsis quinquefolia, woodbine.

Asimia triloba, pawpaw.

Betula lenta, black birch.
Betula nigra, water birch.

Carya alba, shell-bark hickory.
Carya amara, pig nut.
Carya microcarpa, dwarf hickory.
Carya sulcatao, bottom lands, large hickory nut.
Carya tomentosa, black hickory.

Carpinus Americana, ironwood.

Cercis Canàdensis, red bud.

Celastrus Scandens, bitter-sweet.

Celtus occidentalis, hackberry.

Cornus ceircea, kinnikinick.
Cornus florida, dogwood.
Cornus paniculata, swamp dogwood.

Corylus Americana, hazelnut.

Cratœgus coccinea, thorn apple.
Cratœgus crus-galli, cockspur thorn.
Cratœgus tomentosa, black thorn.
Cratœgus tomentosa, *var. punctata*, sharp thorn.

Cupressus thyroides, white cedar.

Dianthua Americana, water willow.

Disspyrus Virginiana, persimmon.

Euonymus Americana, strawberry bush.
Euonymus atropurpurens, wahoo.

Fagus ferruginea, beech.

Fraxinus Americana, white ash.
Fraxinus quadrangulata, blue ash.
Fraxinus sambucifolia, water ash.
Fraxinus virides, green ash.

Gleditschia monosperma, water locust.
Gleditschia triacanthus, honey locust.

Gymnocladus Canadensis, coffee nut.

Juglans cineria, white walnut, butternut.
Juglans nigra, black walnut.

Juniperus Virginiana, red cedar.

Lindera benzoni, spice wood.

Liquidambar styraciflua, sweet gum.

Liriodendron tulipifera, yellow poplar.

Morus alba, white mulberry.
Morus rubra, red mulberry.

Negundo aceroides, box alder.

Planatus occidentalis, sycamore.

Populus alba, silver maple.
Populus heterophylla, cotton tree.
Populus monolifera, cotton wood.
Populus tremuloides, quaking aspen.

Pyrus coronaria, wild crab-apple.
Pyrus angustifolia, narrow-leaved crab-apple.

Prunus Americana, wild plum.
Prunus serotina, wild cherry.

Quercus alba, white oak.
Quercus bicolor, swamp white oak.
Quercus coccinea.
Quercus coccinea, var. tinctora.
Quercus imbricaria, shingle oak.
Quercus macrocarpa, burr oak.
Quercus nigra, black jack oak.
Quercus obtusiloba, post oak.
Quercus phellos, willow oak.

Quercus prinus, chestnut oak.
Quercus prinus, *var. acuminata*, chincapin oak.
Quercus palustris, swamp oak.
Quercus rubra, red oak.

Rhus glabra, smooth sumach.
Rhus toxicodendron, poison ivy.
Rhus typhina, stag-horn sumach.

Robinia pseudacacia, locust tree.

Rosa Carolina, swamp rose.
Rosa setigera, climbing rose.

Rubus Canadensis, dewberry.
Rubus occidentalis, black raspberry.
Rubus strigosus, red raspberry.
Rubus villosus, fall blackberry.
Rubus villosus var humifusus, low blackberry.

Salix humilis, prairie willow.
Salix lucida, shining willow.
Salix nigra, black willow.
Salix petiolaris, petiole willow.
Salix tristis, gray willow.

Sassafras officinale, sassafras.

Tilia Americana, linden, basswood.

Ulmus alata, winged elm.
Ulmus Americana, white elm.
Ulmus fulva, slippery elm, red elm.

Viburnum prunifolium, black haw.

Vitis æstivalis, summer grape.
Vitis cordifolia, winter grape.
Vitis indivisi.
Vitis labrusca, fox grape.
Vitis riparia.

TOPOGRAPHY AND DRAINAGE.

The surface of the county is generally level, or slightly undulating, except along the water courses, where the lands are considerably rolling or hilly. There is no land in the county so rough and broken as to make it necessarily waste land, nor are there any irreclaimable swamps. Originally there were many small swamps or bogs in the northern part of the county, which were fruitful sources of malarial poisons and tormenting insects, but these have about all been reclaimed by draining, and are now among the most productive and profitable lands in the State.

The Wabash River crosses the county from east to west, and divides it into two nearly equal parts, there being seven civil townships, and about an equal number of acres, on either side of the river.

The principal streams south of the Wabash are the Mississinewa River, Little Pipe Creek, Big Pipe Creek and Deer Creek.

The Mississinewa River enters Miami from the southwest corner of Wabash County, flows northwesterly across Butler Township, and empties into the Wabash River about a mile above Peru.

Little Pipe Creek rises in the southern part of Butler Township, flows northwesterly across Butler and Washington townships, and empties into the Wabash about a mile below Peru.

Several branches of Big Pipe Creek rise in the western part of Grant and the northern part of Howard County, and unite in Jackson Township, Miami County. The stream then flows northwesterly, touching the southern part of Butler, the northern parts of Harrison and Clay, and the southern part of Washington Township, thence across Pipe Creek Township and into Cass County, finally emptying into the Wabash River about seven miles above Logansport.

Deer Creek rises in the northern part of Howard County, flows northward into Harrison Township, Miami County, thence westerly across Clay and Deer Creek townships into Cass County, whence it pursues a westerly course across Cass County, and finally discharges its waters into the Wabash River at Delphi, in Carroll County.

The principal streams north of the Wabash River are Eel River, Flower's Creek, Washoni's Creek and Big and Little Wea-Saw's.

Eel River enters Miami County from Wabash County, on the east, flows southwesterly through Richland and Jefferson townships, crosses into Cass County, and discharges into the Wabash River at Logansport.

Flower's Creek rises in Perry Township, flows southerly through Richland Township, and discharges into Eel River just above Chili.

Washoni's Creek rises in the southwest corner of Perry Township, flows southerly through the western part of Richland Township, and discharges into Eel River a short distance below Chili.

Little Wea-Saw's Creek flows southwesterly through the eastern part of Union Township, and unites with Big Wea-Saw's about a mile above the junction of the latter with Eel River.

Big Wea-Saw's Creek flows southerly and southeasterly through Union Township, and discharges into Eel River near the town of Denver.

Besides these described, there are many other small creeks and brooks, in all parts of the county, that perfect the drainage and furnish an abundance of water for the use of the stock of the husbandman.

There are but few rock exposures in the county, the surface consisting almost wholly of glacial deposits—sand, gravel and clay. These materials, which were heterogeneously mixed during the glacial period and at its close, have been largely re-assorted and re-arranged during the lapse of the long ages since the close of the ice age. The entire drift-mass has been greatly modified by re-assortment and re-arrangement; but the surface, the portion subject to the direct action of the elements, has undergone a much greater change in this respect. Changes of topography have been synchronous with the modifications of the drift-mass. Water falling upon the surface, and percolating through the mass, has been the agent that produced the more noticeable changes. The close of the ice age left the surface of the whole of northern Indiana, the drift-area, in a broken, amorphous condition—hills or mountains and high ridges of mud, sand and bowlders, alternated with long, deep grooves and funnel-shaped hollows. Since the close of the glacial period the process of re-modeling the surface of the drift-area has continued uninterruptedly. By infinitely slow processes, the wash from higher portions has filled up the lower, until the whole of the vast area of northern Indiana, and much contiguous territory, has become one vast plain, broken only by the local erosions of the modern streams.

HISTORY.

Miami County derived its name from the Miami tribe of Indians, who, for a long time prior to its occupation by the whites, owned and occupied the land. The land was obtained from the Indians by treaty and purchase. The principal Indian villages in the county were Wea-Saws, at the mouth of Wea-Saws Creek, on Eel River, Squirrel's Village, on Eel River, near the east line of the county, and Flower's Village, on Eel River, near the center of Richland Township, on the north side of the Wabash River; and the Osage Village, on the south side of the river, situated upon the Mississinewa, about a mile above its junction with the Wabash River. The first white settlements in the county were made about the latter village, about the year 1822, or a little later. A number of Indians, who continue to occupy the original reserves, still reside about this place, and there are a number of others in other parts of the county. The Indians residing in the county are educated, intelligent citizens, and in good financial circumstances.

Miami County was organized by legislative enactment in January, 1834; the first session of the Commissioners' Court was held in June, and the first election was held in August, of the same year. The following is a list of the first officers elected to serve the county:

County Clerk: Benjamin H. Scott.
County Sheriff: Jacob Linzee.
County Treasurer: Abner Overman.

County Commissioners: John W. Miller, Alexander Jameson, John Cruidson.

Associate Judges: Jacob Wilkinson, Stephen Shanks.

Joseph Holman was Probate Judge and D. R. Bearss School Commissioner.

In 1827 the first house was erected within the limits of Peru. The town was regularly laid out in 1834. Miamisport, however, now included within the limits of the city of Peru, was platted in 1829.

The Wabash and Erie Canal was completed in 1837, and at once became an important route of transportation, adding very materially to the prosperity and development of the county. Since the great network of railroads has been completed in the county, affording more convenient and speedy methods of transportation, the canal has been abandoned.

The population of Miami County in 1840 was but 3,048; in 1850 it had increased to 11,304; the population in 1860 was 16,851, in 1870, 21,052, and in 1880, 24,083.

GEOLOGY.

The only rocks exposed in Miami County are those belonging to the Devonian and Upper Silurian formations. The Devonian is represented by from 30 to 35 feet of Corniferous limestones, and the Upper Silurian by the Waterlime and Niagara groups. Almost the entire county is covered by a broad sheet of drift, varying in depth from a few feet to 300 feet or more. The few rock exposures are due to the denudations by the streams.

THE DRIFT.

The drift, of course, is the superficial deposit, and is composed of sand, gravel, clay, chalk, or marl, and bowlders, in some places indiscriminately mixed, and in others assorted and re-arranged into beds of sand, gravel or other material.

By far the greater proportion of the vast drift-mass consists of immense beds of stiff, impermeable blue clay. These clay beds, or deposits of *till*, as they are sometimes termed, consist of massive deposits of blue or greenish-blue clay, which in places vary in color through all shades of green to gray and red. The larger part of it, however, is blue, which, upon exposure, weathers to a light gray.

This blue clay is persistent throughout Miami County, wherever there is a material depth of drift, except along the water-courses. As a rule, along the streams the clay was long ago carried away by the force of the running water, and sand or gravel re-deposited in its place. At Denver, on Eel River, in the northern part of the county, Mr. Charles bored a well for water through 125 feet of sand and gravel, without reaching the rock stratum beneath. The water, when obtained, however, was so strongly impregnated with iron that it could not be used. This well was bored in the "bottom," or upon the river terrace Although a number of wells have been bored along this stream to a nearly equal depth, the rock strata have never yet been reached. The material passed through, however, is uniformly the same—sand and gravel. Though the bed rock has not been reached in any of the wells along Eel River, it is evidently true that the sand and gravel deposits extend to the solid rock, and that these materials have taken the place of the blue clay, or other glacial matter, removed by the currents of water.

As frequently stated by writers in these reports, the glacial *debris*, as originally transported to this region, consisted of a heterogeneous mixture of particles, varying in size from the finest dust speck, invisible to the naked eye, to bowlders of gigantic dimensions. This vast mass of mixed material was shoved forward by the irresistible masses of slowly moving ice; and, as the process of tearing up stratum after stratum of solid rock, crushing it into pebbles and grinding it into powder, was contiuued for ages, in regions far north of the limits of this State, the great ice sheet, slowly moving southward, formed a great continental drag, which pulverized the fragments, and scattered the grist from this mighty mill over the vast areas that form the plains of Indiana.

Men can scarcely dare to conjecture the duràtion of the almost infinite period that elapsed, or the number of slowly plodding centuries that dragged their ice locked æon by, while the great continent remained fettered in adamantine ice. Men can not comprehend, they dare not attempt to comprehend, the infinite duration of eternity, the limitless region of space, nor the universal distribution and indestructibility of matter and force; and the long, almost interminable periods of geologic time are almost equally incomprehensible. To attempt to fix the limit, this way or that, or to attempt to fix in years the duration of a geologic period, is the visionary work of folly. By the brook one may pick up a pebble. It is composed of various elements and innumerable atoms of matter. Calcium, carbon, silica, iron and other elements enter into its compound. It is composed of simple, ultimate atoms. They were once all separate, but no one would dare to attempt to fix the period of time that has elapsed since the elements in the stone combined to produce the rock.

Calculations and conjectures and guesses are all equally valueless with respect to the duration of geologic periods, or the actual age of rocks. It is useless, then, to speculate upon the length of time that elapsed during the great Ice Age in America. The evidences that such a period did exist are abundant, and the changes wrought upon the surface of a large part of the continent are of such a character as to force the conclusion that in duration it was almost measureless. But to fix the limit one way or the other, to attempt to point to the beginning and the end, in fact, to attempt to measure its duration in years or centuries, is idle and useless.

Facts, however, are present that are important and convincing. There were long and well defined periods of time when almost continuously uniform conditions prevailed throughout the globe. This is true respecting the temperature and mechanical forces that were in operation during the Ice Age. Almost uniform conditions prevailed during the vast period of the Silurian Age. The same is true of the Devonian, Carboniferous and other periods of geologic time. The present period has been one of uniform conditions for ages that are measureless to man. The recurring seasons, spring and summer, fall and winter, with their periodic changes of temperature and atmospheric forces, with slight seismic and volcanic disturbances, have continued with uninterrupted regularity for countless ages. No one will dare to attempt to measure even the length of time that has elapsed since deciduous trees first appeared upon the earth. How futile, then, to attempt to measure the expanse of an age that begun countless centuries before the appearance of the most familiar works of organic nature.

It is absolutely impossible to measure accurately the duration of the present age, the Ice Age, or any other geologic period.

Men generally concede that the immense deposits of drift scattered over a very large part of North America, are of glacial origin. It is assumed that immense masses of ice accumulated in the elevated regions of British America, and that the force of gravity slowly carried them southward. The process is supposed to have continued for ages. The thickness of the vast ice-river was probably hundreds, and, in places, possibly thousands of feet. In its movement southward with resistless force, it tore up the strata and carried the loosened fragments along in imbedded ice. It formed an immense drag that planed off stratum after stratum of solid rock, and ground the fragments into atoms, scattering the particles over the vast plains of Ohio, Indiana, Illinois and other States. The entire body of the drift seems to be a vast body of morainic matter—the chips and shavings and dust of nature's workshop. The water from the melting ice assorted, carried forward and distributed vast quantities of this morainic matter over regions probably far south of the southern limits of the glacial ice; hence, we find bowlders and pebbles and other matter common to the drift as far south as the Ohio River. Igneous rocks of various kinds, such as are common in the drift, are found scattered all over the southern part of the State, but these should not be taken to indicate that the continental glacier ever reached the extreme limits at which they are found.

The modifying forces that have continued to operate since the close of the Ice Age have materially changed the character of the superficial portions of the drift deposits throughout their entire extent. This is especially true with respect to these deposits along their original southern limits in Indiana, where the residual matter resulting from the disintegration and decomposition of the local deposits has become mixed with the transported glacial matter. But the drift deposits of Miami County are far removed from the Southern limits of the morainic mass, and if the great drift beds are, indeed, of glacial origin, then the superficial deposits of this county have clearly been derived wholly from the same source.

With respect to the elements that go to make up the drift formation in Indiana, the principal are silica, alumina, lime and iron. The silica is found principally in the clays, sands and bowlders; the alumina in the clays and bowlders; the lime in the clays, marls, chalk, and the peat-like, swamp deposits, while the iron is abundant in the swamps in the form of bog ore, in gravel deposits, and in the clays and water. Other elements besides these, of course, enter into the composition of the drift, but from an economic point of view they possess little importance. Of the elements of the drift mentioned above, the silica and alumina are largely of foreign origin. They have been derived chiefly from the destruction of rocks belonging to other deposits than those found in this State. The iron, also, might have been derived from the same source, but the lime, which occurs in the drift in large quantities, in the form of chalk or marl, or other combinations, has evidently been chiefly derived from the deposits of limestone occurring in the State. The same forces that broke up the rocks in regions beyond the limits of the State, and ground the fragments into dust, continued their operations throughout Northern Indiana, tearing up the limestone strata and pulverizing the fragments of limestone as though they were between the stones of an enormous mill.

THE CLAYS.

The clay deposits extend over the greater part of Miami County. In some localities the clay beds appear at the surface, and in others layers of gravel or sand, or accumulations of lacustral matter, or peaty deposits lie over them.

There is considerable variation in the character of the clays exposed at different points throughout the county. Mr. John E. Milliron, of Denver, to whom I am especially indebted for valuable information and assistance, has given, for a number of years, great attention to the mineral resources of the county, and especially to the clays. He has collected many varieties of clay from the northern part of the county, and had careful analyses made of some of them by competent chemists, and other samples have been put to careful practical tests. Clay suitable for a good article of pottery occurs at several points near Denver, while tile and brick clays of most excellent quality may be found in almost any part of the county.

An ochreous kind of clay, very fine in texture and highly colored with iron, which makes an excellent mineral paint, suitable for barns, out-buildings, bridges and other similar work, is found in inexhaustible quantities. This paint has been used at Denver to some extent, and proves to have most durable properties. It only needs to be properly mixed with oil to be ready for use, and is applied with a brush as readily as any other kind of paint. A profitable industry might be built up in the manufacture of this paint for the purposes mentioned above. Mr. Milliron has given the matter careful attention, and his experiments with the paint have been highly satisfactory in every way.

There is a fine deposit of clay on the farm of Mr. Abram Alley, four miles northwest of Denver, on Wiesaw Creek, that may be profitably used in the manufacture of pottery, and is certainly valuable for the manufacture of tile and brick. It burns to a light cream color, stands the fire well, does not warp materially, and may be burned to any degree of hardness.

Mr. Milliron found on the same farm a vast quantity of a brownish-colored clay, which burns to bright red, and makes a most excellent paint. This same variety of clay occurs also on the farm of Louis Piper, two miles north of Denver, and on the farm of Wm. Zook, one mile north of Denver. It also occurs in the vicinity of Chili, in inexhaustible quantities.

THE SAND.

Sand in vast quantities occurs along the various streams throughout the county, and at other points where it occurs in the drift in lenticular beds. Much of it is valuable for the builders' use, and it is quite likely that considerable deposits of it occur that may be successfully used for the grinding of glass or for moulders' use. In view of the fact that there is an increasing demand for glass sand of good quality at the many large glass factories recently located throughout the gas fields, it is a matter of importance that careful search should be made for this valuable material throughout the entire State. At the present time by far the larger portion of all the sand used in the manufacture of glass is transported from points outside of the limits of Indiana. At a number of points in this State glass sand of good quality is found in large quantities, and it is quite probable that it occurs in many other places. Quite an item of expense might be saved to the manufacturers in the way of freight charges if sand of suitable quality could be procured in this State, and at the same time material benefits would accrue to those who might be able to supply the required material.

IRON ORE.

Bog iron ore in considerable quantities occurs throughout the northern part of the county. In the earlier days of the county furnaces were in operation along Eel River, and a considerable quantity of excellent iron was manufactured, but owing to the expense of collecting the ore the furnaces had to be abandoned.

WATER.

The many streams flowing through the county furnish an ample supply of excellent surface water for stock, while springs abound in many sections. Every sand stratum in the drift deposits contain more or less water, and by boring or digging until a good stratum of sand is found lying underneath a bed of impervious blue clay, an inexhaustible supply of excellent water is almost certainly obtained. In many instances the water rises to the surface and flows out, thus forming an artesian well.

In many localities the water is strongly impregnated with salts of lime, iron or other mineral matter, though, as a rule, these elements do not enter sufficiently into its composition as to render it unfit for domestic or manufacturing purposes.

DEPTH OF DRIFT.

South of the Wabash River the drift varies in depth from nothing to 100 feet or more, though it is only along the streams where it has been carried away by water that it is wholly wanting. At Bunker Hill, Gas Well No. 1, it is 58 feet thick; at Xenia it is 50 feet thick, while at Amboy, midway between the two points, it is 35 feet thick.

The alluvial matter in the Wabash River bottom varies from 5 to 50 feet in thickness. In Gas Well No. 2, at Peru, it is 10 feet thick; in Well No. 1, Northside, it is 36 feet thick, while at the Bearss Gas Well, No. 4, bored on the high lands two miles north of Peru, the drift is 324 feet thick. It is quite likely that the maximum thickness of drift north of the Wabash River in Miami County will approximate 400 feet in thickness, even if it does not exceed that depth.

DEVONIAN LIMESTONE.

The only rocks of the Devonian formation that are exposed in the county occur along Big Pipe Creek from the vicinity of Bunker Hill to the county line. Following Big Pipe Creek down towards its junction with the Wabash River, the Corniferous limestones are exposed at many points in Miami and Cass Counties. Near the mouth of the creek, in Cass County, the waterlime are the surface rocks. North of Bunker Hill, on Big Pipe Creek, and for a distance of about three-fourths of a mile along the creek, are almost continuous exposures of Corniferous limestone.

The larger proportion of the rock along the streams in this vicinity is a bluish gray limestone, somewhat crystalline in structure, and much of it is well adapted to rough masonry, such as bridge abutments, foundations and other similar work. A short distance below the railroad bridge there is an exposure of a light-gray, shaly limestone, remarkably full of fossils, many of which are in an excellent state of preservation, *Phillipsia bufo* is quite common in these rocks, in which also occur several species of *Zaphrentis* and other cyathophylloid corals. Many species of *Spirifera* and other brachiopods are also present. I also found at this outcrop several fish teeth, fairly well preserved, and three or four vertebræ. This exposure of fossil-bearing rocks is very small, and lies immediately upon massive beds of sub-crystalline limestone.

At Wright's old limekilns, one-half mile below the Champion mills, on Pipe Creek, there is another exposure of Corniferous limestone. At this point the exposed strata are about 16 feet in thickness, of which the following is a section:

Gray, fossilliferous limestone	4 feet.
Bluish-gray silicious limestone (hornstone)	12 "
Total	16 feet.

The fossil-bearing rocks at this exposure contain the same species found in the fossil beds near Bunker Hill, but, as a rule, the fossils are not nearly so well preserved. The fossils serve to show, however, that the stratum containing them belongs to the same geological horizon as the Bunker Hill beds.

The silicious strata lying underneath the fossil beds vary in thickness from three or four inches to a foot or more. They are too cherty for the builder's use, except for rough masonry.

About a mile above the "falls" on Pipe Creek there is an old stone quarry, from which may be obtained building stone of fairly good quality. This stone is highly crystalline in structure, and has been quarried to some extent for local use under the name of "marble." Blocks of large dimensions may be obtained, and the quarry might be made fairly profitable if there were ready means for transporting the stone. Fossils are quite abundant here, characteristic of the Corniferous limestones, but they are usually so firmly imbedded in the matrix that they can not readily be obtained.

Further down the creek, at Stewart's Mills, in the edge of Cass County, there are high bluffs of Corniferous limestone, varying but little in general characteristics from the crystalline rocks mentioned above. At Costenborder's mill, a few hundred yards below Stewart's mill, there are 20 feet of Waterlime, or Lower Helderburg rocks exposed in the bluffs of the creek.

As a rule, the Corniferous limestones along Big Pipe Creek are too cherty and silicious to make good lime, but there are two or three localities where fairly good lime has been made of the gray, fossiliferous limestones that overlie the cherty deposits.

There is but little, if any, evidence of disturbance in the Corniferous limestones exposed along Pipe Creek. The rocks, as a rule, lie almost horizontally, although in places there is quite a perceptible dip to the west or southwest, and occasionally the rocks are slightly inclined to the north.

The Corniferous limestones were reached in the gas well at Bunker Hill at a depth of fifty-eight feet, but as the Waterlime and Niagara limestones lie immediately under them, it was found impossible to determine from the drillings brought up the exact thickness of the Devonian rocks, on account of the fact that the particles collected were too small to afford fossils or other distinguishable features of either formation.

WATERLIME.

These rocks are exposed along the Wabash River for a distance of about a half mile above the Lake Erie & Western R. R. bridge, and about one mile west of Peru. There are three quarries in operation here—the Kazell quarry, Brownlee's quarry, and the O'Donnell quarry. O'Donnell's is the upper and Kazell's the lower quarry. The position of the rocks in all these quarries is nearly horizontal, there being but a slight dip, and that toward the south. The ledges or layers are from three to sixteen inches in thickness, and slabs may be quarried of any desired dimensions. The stone is a hydraulic limestone, bluish in color, of fine, even texture, with occasional dark veins that run parallel with the plane of stratification. It is well adapted to foundation work, bridge abutments and all similar work, and, indeed, would make a fair building stone. The thin layers make a most excellent flagging stone, admirably suited for sidewalks, for which it is extensively used. The thickness of the exposed strata is fourteen feet, but the total thickness of the Waterlime at this point has not yet been ascertained.

The Waterlime, like the Carboniferous limestone, shows very little evidence of disturbance. Wherever these rocks are exposed they appear to lie just as they were originally deposited. They were evidently deposited at the close of the period of disturbance that tilted and distorted the Niagara limestones in the immediate vicinity.

NIAGARA LIMESTONE.

Exposures of Niagara limestone occur along Little Pipe Creek near its junction with the Wabash River, and at several points along the Wabash River in the vicinity of Peru. The same limestones are exposed at many points along the Mississinewa River.

At Wallick's Mill, on Little Pipe Creek, about a mile south of the Wabash River, and near the Lake Erie & Western R. R. track, there is an extensive exposure of Niagara limestone. The rocks are tilted and greatly distorted. The dip varies from 30° to 50°, and the general direction of the incline is to the north or northeast. The rapid dip of the Niagara here carries it below the level-lying Waterlime at the river near a mile north. The total thickness of strata exposed, measured across the upturned edges, is about 150 feet. The altitude of the highest Niagara rocks exposed here is probably 125 feet greater than that of the top of the Waterlime rocks exposed in the banks of the river. The dip of the Niagara rocks, as stated, varies from 30 to 50 degrees, while the Waterlime rocks lie in an almost horizontal position. What dip there is to the Waterlime is to the South. It is probably at the rate of one foot in twenty-five. In view of the fact that Niagara rocks are more than 100 feet higher than the Waterlime, and of the rapid dip of the former toward the north, while the Waterline lies nearly horizontal, can any one question the fact of the upheaval of the Niagara limestones, and the subsequent deposition of the Waterlime? The exposure here is no isolated example of the disturbance of the Niagara strata. At other points in Miami County, in Wabash, Huntington, Wells, Adams, Blackford, Carroll and Newton counties, the same phenomena are exposed. At every point, almost, throughout all this region, where the Niagara limestones are exposed, they show more or less evidence of disturbance. The strata are more or less tilted, and broken to a greater or less extent at every point. In some places the layers of stone are almost vertical, and in others but little dip is perceptible. In some places the rocks have been so broken by some crushing destructive force that scarcely a piece can be found large enough for the builders' use, while in other localities a slight dip, and long, frequent vertical seams, with occasional cross seams, are about the only evidence of disturbance; but throughout the whole extent of the Niagara exposures in all this wide reach of territory, the evidence of a marked disturbance, most general in its character, is everywhere present.

The stone exposed in the vicinity of Wallick's mill is a grayish colored limestone, sub-crystalline in structure, and contains many casts of characteristic fossils, the most common of which are *Calymene niagarensis*, *Favosites niagarensis* and several species of brachiopods. It makes a very good quality of lime, and limekilns have been in operation here for many years.

For building purposes this stone is not desirable, although fair foundation stones might be obtained here; but the rough, amorphous condition of the rocks, coupled with the fact that they are most difficult and expensive to work, makes quarrying at this point almost wholly unprofitable.

The Niagara limestones are exposed at Trippier's limekilns, on the south side of the Wabash River, about one-fourth of a mile east of Peru. The exposures occur in the bluffs of the stream, and are of considerable extent. The stone quarried here is used almost wholly in the manufacture of lime. The kilns are owned by Mr. Charles Trippier, and the lime he manufactures is of excellent quality. The rocks contain quite a number of fossils, and I succeeded in procuring specimens of *Eucalyptocrinus crassus*, *Caryocrinus ornatus*, *Spirifera radiata*, *Spirifera eudora*, *Calymene niagarensis* and several other species there.

There is the same distorted condition of the strata here that has been noted as occurring wherever the Niagara rocks are exposed along the Wabash River. The rocks are tilted to the extent of about twenty-five degrees, the dip being west by southwest.

One-fourth of a mile east of Trippier's, on the south side of the highway, occurs another exposure of Niagara limestones. The rocks here are easily identified by the fossils they contain, the same species occurring as are found at Trippier's. The rocks at this place are strongly inclined to the west, probably to the extent of 40 or 45 degrees.

The Niagara limestones are again exposed at the highway bridge over the Mississinewa River, about one-fourth of a mile east of the exposure last mentioned. At the bridge, however, the direction of the dip has changed to the east, showing that there is arch or anticline in the strata between the bridge and the exposure further west. The dip of the strata at the bridge is just 25 degrees, the incline having been accurately measured by Mr. Ed. Hiller, of Peru, with a clinometer. Mr. Hiller is a very competent gentleman, who has given considerable time to the study of the geology of Miami County, and especially to the structural features of the exposed strata. He has examined every outcrop of rocks, and given particular attention to the tilted and broken strata of the Niagara group.

The limestones in the vicinity of the Mississinewa bridge are dolomitic, occur in thin layers, and are considerably broken. They are hard, rough and difficult to work. They are suitable only for foundation work in masonry, but the thin layers are to some extent adapted to flagging purposes. But few fossils have been found in them, and those were Niagara brachiopods.

The Niagara limestones are exposed in the banks of the Mississinewa River at "The Cliffs," four and a half miles southeast of Peru. Here the strata are thin and lie in an almost horizontal position. The strata are broken by numerous irregular vertical seams. I found no fossils here myself, but Prof. Hooper, formerly City Librarian at Indianapolis, at one time collected a considerable number of fairly well preserved Niagara fossils at the foot of the principal ledge of rocks. By the fossils, which, as stated, were fairly well preserved, Prof. Hooper was able to readily identify the rocks.

The rocks at the Cliffs are Dolomitic limestones, hard and sub-crystalline in structure. They are only fit for foundation work or flagging, and have never been quarried to any great extent for any purpose. The total thickness of the strata exposed here is about twenty-five feet.

About a mile below the town of Peoria, and a short distance above the second bridge across the Mississinewa River, occurs another exposure of Niagara limestone. The rocks exposed at this point form the north bluff of the stream. The thickness of the exposure is about forty feet, and extends for a fourth of a mile or more along the stream. The bottom layers are cherty limestone about twenty feet in all, with about twenty feet of heavy bedded stone above. The exposed rocks lie in the form of an arch, with the strata dipping east and west from the center.

At Peoria there are limited exposures of Niagara limestone, containing much chert, along the west bluff of the stream. The total thickness of the strata exposed here is about thirty-five feet, but the points of exposure are small, the rocks being covered by accumulations of clay and soil—the debris forming a steep slope.

The next exposure of rocks along the Mississinewa occurs about one mile above Peoria, and one-eighth of a mile east of the Miami County line, in Grant County. The rocks are exposed on the north side of the stream, the thickness of the strata being about forty-five feet. There is a southeasterly dip at this place of about ten degrees.

The Niagara limestones of Miami County do not possess the properties of valuable building stone, although they may be profitably used for foundations, or other rough work. The Waterlime rocks near Peru, however, are much better even for the roughest work, consequently there have been no special efforts made to develop a quarrying industry along the Mississinewa River.

For the manufacture of lime the Niagara limestones furnish excellent material at many points along the Wabash and Mississinewa Rivers, and several parties have made profitable use of the advantages afforded.

NATURAL GAS.

The citizens of Miami County were among the first in the State to begin an active search for natural gas. When the fact became known that gas was to be found in paying quantities in this State, by drilling down to the Trenton limestones, the citizens of Peru promptly organized a stock company with sufficient capital, and at once began to prospect for the valuable fuel.

As no one was able to determine beforehand just where gas was to be found in commercial quantities, the rule over the state was to locate the first well at a spot most convenient for piping. If gas was not found in the first attempt a second effort would be made and the next well located at some little distance from the first. With the knowledge obtained by drilling the first well, the second was usually completed in less time, and at a reduced expense. Advantage was taken of every fact bearing upon the conditions under which gas was found in localities that produced it abundantly, and a second, third or fourth well was usually located with reference to the structural features of the surface.

The first well drilled for gas in Miami County was located in the northern part of the city of Peru. The altitude of the surface at this well is 657 feet above sea level. The following is a record of the strata passed through in drilling:

SECTION OF WELL No. 1, PERU.

Alluvium—River drift	36 feet.
Niagara limestone	385 "
Hudson River and Utica	454 "
Trenton limestone	30 "
Total depth	905 "
Top of Trenton below sea level	218 "

In this well a small quantity of petroleum was found at a depth of 880 feet, five feet below the top of the Trenton limestone. Salt water in large quantity was struck at 900 feet—25 feet in Trenton. It failed to produce gas.

Well No. 2 was located just south of the city, and about one and one-fourth miles from No. 1. The altitude of the surface at well No. 2 is 700 feet above sea level. The following is a record of the strata passed through in this well:

SECTION OF STRATA IN GAS WELL No. 2, PERU.

Soil and gravel	10 feet.
Waterlime and Niagara limestone	410 "
Niagara (?) Shale	45 "
Clinton (?) limestone	15 "
Hudson River and Utica	449 "
Trenton limestone	27 "
Total depth	956 "
Top of Trenton below sea level	229 "

Failing to get gas in well No. 2, the prospectors concluded that it was not to be found in large quantities in the immediate vicinity of the city.

The next point selected was on the Yonce farm, about seven miles south-east, and in the direction of the Amboy and Xenia gas fields. The following is a section of the Yonce well, No. 3:

SECTION OF GAS WELL, No. 3.

Drift	70 feet.
Limestone—Waterlime and Niagara	490 "
Hudson River limestone and shale	250 "
Utica shale	150 "
Trenton limestone	42 "
Total depth	1,002 "

The altitude of the surface at this well was never accurately measured, so that the depth of the top of Trenton below sea level could not be determined. Gas was obtained in quantity sufficient to make a flame four or five feet high. Salt water was struck at a depth of 1,000 feet, 40 feet in Trenton, and raised to the surface, but did not flow out.

By comparing the sections given of wells Nos. 1 and 2 at Peru, it will be observed that the top of Trenton limestone is 11 feet lower in well No. 2 than it is in No. 1, as compared with sea level. Wherever the rocks are exposed along the Wabash river, near Peru, there is a west by southwest dip, and in some places the tip is very rapid, showing facts of remarkable disturbance. As well No. 2 is south of No. 1, this west by southwest dip carries the Trenton of well No. 2 to a lower geographical horizon than that of its occurrence in No. 1. Investigations of the prospectors in the vicinity of Peru led them to conclude that owing to the tilted and broken condition of the strata in the neighborhood of the city, the probabilities were that if gas ever had been confined in the strata of the Trenton limestones in that vicinity, it had virtually all escaped through the cracks and fissures of the upturned strata. The results of the drilling of wells Nos. 1 and 2 showed a considerable dip of the rocks toward the south. It was thought, therefore, that the summit of an arch in the strata might be found by going some distance north, consequently well No. 4 was located upon the Bearss farm, about three miles north of the city. At this well an extraordinary thickness of drift was found over the stratified rocks.

The following is a section of the strata encountered in the Bearss well:

SECTION OF THE BEARRS WELL, No. 4.

Drift		324 feet.
Niagara		379 "
Hudson River and Utica		307 "
Trenton		31 "
Total depth		1,041 "
Depth to Trenton	1,010 feet.	
Altitude of surface	757 "	
Top of Trenton below sea level	253 "	

No gas nor oil was found in this well.

Wells Nos. 1 and 4 were the only ones bored north of the river in Miami county. The experiments so far made demonstrated the fact fully that gas was not to be found in paying quantities in the immediate vicinity of Peru. The citizens, therefore, concluding that gas was a necessity, promptly proceeded to organize a company with sufficient capital to drill wells in the developed gas area in the extreme southern part of the county and pipe it to the city. This line was projected to the vicinity of Xenia and completed some months ago, and the city is now as well supplied with gas for all purposes as any city in the State.

The company was organized with a capital stock of $100,000, but the total amount required to drill the wells, lay mains and distribute the gas exceeded $200,000. More than forty miles of pipe are used in principal and distributing mains. The company has facilities for extending their mains to the center of the gas area, and Peru is assured of natural gas in abundance as long as the great reservoir of Indiana continues to supply it.

BUNKER HILL GAS WELL.

The Bunker Hill well was drilled in 1887. There was a careful record kept of the strata encountered in drilling the well, by Professor Neff, superintendent of schools at Bunker Hill.

The altitude of the railroad track near the well is 837 feet above sea level. The surface at the well is about six feet lower, or 831 feet below sea level.

The following, by Prof. Neff, is a record of the strata encountered in drilling the Bunker Hill well:

SECTION BUNKER HILL GAS WELL.

Drift—soil, clay, sand, etc.	58	feet.
Limestone, Corniferous, Waterlime, Niagara	503	"
Hudson River limestone and shale	389	"
Utica shale	42	"
Trenton limestone	12	"
Total depth	1,004	"
Top of Trenton below sea level	161	"

This well produced no gas nor oil, but salt water was struck in the Trenton, which raised to within 20 feet of the surface, or to an altitude of 811 feet above sea level.

GAS AT AMBOY.

There are several strong natural gas wells at Amboy and vicinity. The first well drilled there produced near 2,500,000 cubic feet of gas every twenty-four hours. The gas was perfectly dry and free from oil. This well was drilled in the fall of 1887. As there is but little difference in the thickness and character of the strata encountered in the several wells drilled in that vicinity, the "log" of well No. 1, at Amboy, will be given as an example of all:

SECTION OF GAS WELL No. 1, AMBOY.

Drift	35	feet.
Waterlime and Niagara limestone and shale	350	"
Hudson River and Utica	522	"
Trenton limestone	33	"
Total depth	940	"

In this well the drill passed through about 85 feet of shale near the bottom of the Niagara. This was followed by 12 feet of limestone, possibly Clinton, which contained a large amount of salt water. This salt water was cased off, after which the drillers had no further trouble on account of water. At the time this report goes to press there are some five or six productive gas wells in the vicinity of Amboy. The depth of Trenton limestone below sea level is 100 feet in Well No. 1.

GAS AT XENIA.

Xenia was the first point in Miami County to secure natural gas. The first well was drilled there in the summer of 1887. The following record of Well No. 1, at Xenia, fairly illustrates the character of the strata in that locality:

SECTION OF GAS WELL No. 1, XENIA.

Soil	4	feet.
Gravel	46	"
Waterlime	31	"
Niagara	238	"
Hudson River and Utica	587	"
Trenton limestone	31	"
Total depth	937	"
Altitude of surface at well	815	"
Trenton below sea level	91	"

The flow of gas from this well was rather weak. Water was reached in the Trenton limestone soon after gas was found, and, rising in the bore above the gas-bearing stratum, materially checked the flow of gas.

Water was found in the Niagara limestone, but this was cased off, and, rising outside of the casing, flowed out in a strong stream.

The second well drilled at Xenia was a strong one, yielding dry gas in sufficient quantity to supply the entire town.

The Peru Company has drilled several wells in the vicinity of Xenia, some of which are very powerful. As a rule the wells drilled in this locality are dry, that is, there is not much, if any, water found in the Trenton rocks.

The experiments of the citizens of Peru, and of the towns in the southern part of the county, were valuable to science, in that they demonstrated, or defined, rather, the northern limits of the gas area in that region. They most clearly demonstrate the fact that gas is not to be found in paying quantities along the Wabash River, nor near it.

On the farm of Mr. Al. Morris, two and a half miles south of Peru, a well was bored for water to the depth of 100 feet. Solid rock was not penetrated, but a strong flow of gas was found at the depth of 100 feet.

When lighted the flame was three or four feet high, and burned continually. The gas was probably generated in one of the so-called buried swamps, common in the drift of Indiana.

ARCHÆOLOGY.

The Aborigines of Miami County left but few monuments to perpetuate their memory. Occasional mounds are about the only earthworks, and these, or the greater part of them, are in the southern part of the county. As a rule the mounds observed are merely small, conical hillocks, varying in height from two to five feet, and in diameter from twenty to fifty feet.

Implements of stone are not rare, but they are by no means so plentiful as they are in some other parts of the State. Stone axes of the grooved pattern are sometimes plowed up in the fields, or picked up in other places, and the smooth form of axe, or scraper, peeler or flesher, as it is sometimes termed, are frequently found. Flint arrow and spear heads of various patterns, including the barbed, stemmed, rotary, serrated, triangular and leaf-shaped forms, are common, though not plentiful.

Pottery has only been found in fragments, and pipes are very rarely found. Perforated and polished pieces are rare. The Indian or Mound Builder of Miami County was an economical kind of a citizen, and did not throw his implements of war or the chase away recklessly.

NATURAL GAS AND PETROLEUM.

BY S. S. GORBY.

The application of natural gas to economic use for heating and lighting purposes, at Pittsburgh, Pa., a few years ago, soon resulted in a complete revolution of the fuel business in that city and vicinity. The new fuel was so readily adapted to all kinds of manufacturing, it was found to be so cheap and convenient that it at once supplanted all other kinds of fuel in use. The "City of Smoke," on account of the cleanliness of natural gas as a fuel, become immediately a city of sunshine.

Careful experiments were made in every line of manufactures, and it was found that natural gas answered nearly all the purposes of wood, coal and coke. The value of the new fuel having been ascertained, an active search for it was at once commenced in every locality that gave a promise of success. It was known that gas abounded in the petroleum-producing areas of Pennsylvania, and into those fields the drillers again entered, and began their search for gas with the same energy and success that attended the pioneer efforts of the oil drillers during the earlier periods of the oil excitement. The Murraysville and other gas fields contiguous to Pittsburgh, were developed immediately, and pipes were laid to convey the gas to the city.

The appliances and fixtures for the use of natural gas in furnaces, stoves, etc., are simple and cheap, and easily adapted to furnace, stove or grate. Various devices have been invented for the use of gas in stoves and grates, and where the plumbing is properly done, accidents can only occur on account of the gross carelessness of those who start the fires. Automatic regulators have been applied, by which the temperature of a room may be continued at the same degree, with scarcely any variation, for an indefinite period of time. The cheapness of natural gas, together with its convenience, makes it the most desirable fuel known. It requires no store-house, nor handlers, produces no ashes nor other waste matter, and if proper care is exercised, may be used for domestic or manufacturing purposes with as much safety as any other fuel.

The demand for gas in the Pennsylvania areas is enormous, and the supply is fully equal to the demand—hundreds of millions of cubic feet being consumed daily. From the Pennsylvania fields the search for gas extended to portions of New York, Ohio and West Virginia, resulting in the discovery of large areas of gas-producing territory in each of those States. The gas-producing rocks of New York, Pennsylvania, West Virginia and Eastern Ohio, as the developments exist at the present time, extend from the base of the Coal-Measures down to and include the Devonian. The gas-producing rocks of Western Ohio and Eastern Indiana lie far below in the Lower Silurian formation. The petroleum and gas of Western Ohio and Eastern Indiana have been derived from the decomposition of organic remains that were deposited in the sediment that now forms rocks vastly older than the rocks of the Pennsylvania fields. Many layers of impervious shales and other rocks lie between the horizons of the gas-bearing rocks of Indiana and those of Pennsylvania.

The paleozoic rocks of Indiana, the only rocks that are exposed at the surface in this State, or that are penetrated by the drill in boring for gas or water, with their superincumbent deposits of drift, consist of the following series:

Quarternary	Drift, sand, gravel and clay	0 to 400 feet.
Coal-Measures	Upper Coal-Measures	50 to 196 "
	Middle Coal-Measures	600 to 888 "
	Lower Coal-Measures—Conglomerate	60 to 210 "
Sub-Carboniferous	Chester sandstones and limestones	0 to 100 "
	St. Louis limestones and shales	0 to 330 "
	Keokuk limestones	6 to 106 "
	Burlington limestones (?)	0 to 20 "
	Knobstone—sandstone	12 to 532 "
Devonian	Genessee, Hamilton and Marcellus shale	60 to 420 "
	Corniferous limestone	5 to 84 "
Upper Silurian	Lower Helderberg—Waterlime	0 to 80 "
	Niagara limestone	20 to 728 "
	Clinton limestone	0 to 40 "
Lower Silurian	Hudson River limestone and shales	185 to 715 "
	Utica shales	25 to 380 "
	Trenton limestones	451 to 626 "
	Potsdam sandstone	300 to —— "

In the series of rocks given above the maximum thickness of the different groups is given in the last column. The drill within the last year has shown that the Devonian shales are about three times as thick in the northern part of the State as they were supposed to be, estimating from the known thickness of these rocks further south. The Niagara limestones and shales, also, are more than twice as thick in the northern and northeastern parts of the State as they are in the central part of the State, where their thickness was known. The drill has shown, too, that the Hudson River limestones and shales have a maximum thickness of more than 700 feet in the eastern part of the State, and the Utica shales have a total thickness of about 400 feet in many places. Summarizing, the geological formations of Indiana, so far as known at the present time, have a maximum thickness as follows:

Drift	400 feet.
Coal-measures	1,300 "
Sub-carboniferous	1,100 "
Devonian	500 "
Upper Silurian	850 "
Lower Silurian to bottom of Trenton	1,720 "
Total	5,970 "

Natural gas, in greater or less quantities, is found in every county in Indiana, and it is well known that it occurs in every geological formation from the drift down to and including the Trenton limestones. Throughout several counties of the State it is found in the Trenton rocks in enormous quantities. The Trenton rock gas-producing area of Indiana is one vast, connected field, embracing more than a dozen counties and containing an area of about 5,000 square miles. Throughout all this area the initial pressure, or rock pressure, is about the same. The average pressure is about 320 pounds. Where the gas-producing rock is quite porous, and has a thickness of several feet, the closed pressure will run to 320 pounds, or there about, in one or two minutes. Where the rock is very close in texture it requires several hours to accumulate the same pressure. In some instances even days would be required to accumulate the maximum pressure. But where wells all draw from the same reservoir, as all the wells of Eastern Indiana evidently do, if the wells are all shut in for a considerable length of time they will all finally show about the same pressure in pounds.

When gas was first found in Indiana, at points considerably remote from each other, various inaccurate methods were adopted to ascertain the initial pressure of the gas, and it was thought by many that this pressure determined positively the amount of gas that would flow from a well in a given time. For instance, it was thought that a well showing 200 pounds pressure on a steam gauge would flow twice as much gas as one measuring only 100 pounds, and if a well of 100 pounds pressure would flow 1,000,000 cubic feet per day, then a well of 200 pounds pressure would flow 2,000,000 cubic feet per day and so on.

The inaccurate measurements and estimates reported were calculated to create the impression that there is a multiplicity of gas reservoirs in the State, with initial pressures varying from 200 pounds to 600 pounds per square inch. More careful measurements, however, have recently been made, and these show that the initial pressure of the great Trenton rock gas field of Indiana is about the same at all points, viz., about 320 pounds per square inch. This immense field, extending from Portland to

Kokomo, and from LaFontaine in Wabash County, southward to Greenfield, Morristown, Greensburg, and even to Lawrenceburg, expanding, to some extent, beyond all these points, evidently consists of one vast connected reservoir. If all the wells within this vast area were kept closed for a period of several days, there would be but little difference of pressure shown by the gauge after the full accumulation of gas had been secured in each well.

While the initial pressure of the gas (that is, the pressure of the gas in its compressed condition as it is confined in the rocks) determines to a large extent the volume of gas that issues from a well, there are other conditions existing which also largely determine the amount of gas which flows from any well. One of these conditions, and one, too, of the utmost importance, is what is termed the *porosity* of the rock that forms the reservoir. It has been claimed by some geologists of eminence that *porosity* is a condition unknown in limestones; in other words, it has been denied that there are such things as *porous* limestones. It is quite clear that those who entertain such an opinion have never had an opportunity to examine the fragments of rock brought up by the sand pump from the Trenton limestone, nor pieces from the same formation that have been blown out by the gas. The gas-producing rock is composed of small granular crystals, varying in size, and the manner in which the crystals unite and interlock forms a net-work of small interstices, which are the so-called pores. All our limestones are *porous* to a limited extent. They will all absorb more or less water and gas or air, and any rock that will absorb gases or liquids is *porous*. Where the rock is very close in texture, however, it so obstructs the movement of gases through its mass that, although the initial pressure of the gas confined within it may equal the maximum, the flow of gas from such rock will necessarily be small. A very open, porous rock permits free movement of the gas and makes a strong well, while a close grain or texture will obstruct the flow largely, and the result is a small well.

In addition to the initial pressure of the gas and the porosity of the rock, there is one other thing essential to the largest productiveness of a well, and that is a considerable *thickness* of porous rock; and to insure the largest returns the drill must penetrate entirely through the porous rock. The gas-producing stratum of Trenton rock in Indiana varies greatly in thickness. In some localities the porous rock is only a few inches or a few feet thick, while in other localities it is twenty-five or thirty feet thick. All will readily recognize the fact that where two wells are drilled into rock of exactly the same texture, and where the initial pressure of the gas is the same in each, that if in one the drill penetrates twenty feet of porous rock, and in the other only four feet of porous rock is passed through, that the flow of gas will be several times as strong from the first well as from the second. The three things, then, that modify the productiveness of a gas well are:

First. The initial pressure of the gas.
Second. The porosity of the rock.
Third. The thickness of the porous rock.

The horizon of the gas in the Trenton limestones of Indiana is near the top of the formation. If gas is not found within a few feet of the top of the series, it is not found at all in paying quantities. And I have observed in this connection that wherever, in Indiana, a porous rock is found immediately after reaching Trenton, gas is always present in paying quantities. If the rock is moderately close in texture a small flow of gas is obtained, and where the rock is very close no gas is found. A slight flow of gas, from a moderately close-grained rock, may, in many instances, be made a paying well by exploding a heavy cartridge of nitroglycerine in the bore at the horizon of the gas. If the well has been drilled to a considerable distance below the gas horizon, it is necessary to pack it below, so that the cartridge will rest exactly at the horizon of the gas. The effect of the discharge is to shatter the rock for several feet in every direction from the bore, which will permit a freer and much stronger movement of the gas. The volume of escaping gas is, as a rule, greatly increased by the explosion. In some instances, wells that could scarcely have been termed paying, have been made very valuable by shooting.

Another condition necessary to secure gas in large quantities is an impervious covering of shale, or other rock. The reservoir must also be bounded on every side by impervious strata, and the underlying rocks must be equally impervious. The reservoir must consist of porous rocks, bounded above and below, and on every side, by impermeable strata. The covering must be sufficiently thick to give the necessary weight to compress the gas, and confine it. These conditions are absolutely necessary, for without them the gas would expand to an unlimited extent, and its value would be wholly lost for economic purposes.

THE ORIGIN OF GAS.

It is generally recognized among geologists and others that gas and petroleum have the same, or a common, origin. The two substances are always found associated together, sometimes both occupying the same reservoir, and again seemingly occupying separate but closely connected reservoirs. They have a vertical range through all formations of stratified rocks. Indeed, they seem to be wholly confined to the sedimentary deposits. The drill has penetrated the azoic rocks in many places, but I have yet to learn that gas or petroleum has ever been found in quantity below the sedimentary accumulations. In view of these facts, the conclusion must be that gas and petroleum have had their origin in the rocks that confine them. From what substances, then, have gas and oil been derived? The only known substances that could be drawn from by nature, at the present day, in the manufacture of oil or gas, are animal, vegetable or mineral. It is well known that all forms of organic matter contain more or less of the elements of both oil and gas. Many forms of animal life, and many forms of plant life, are large oil producers. All forms of organic matter decompose spontaneously, and it is well known that, in the decomposition of matter, gas is generated. It is also well known that vast amounts of organic matter, both animal and vegetable, were deposited with the sediment that forms the stratified rocks. During many periods of the formaton of the sedimentary rocks, organic matter decomposed very slowly. So slow, indeed, did the bodies decompose, that, as atoms were eliminated, one at a time, in the form of gas, an atom of mineral matter, lime or other substance, slipped into the place made vacant by the eliminated atom, and, being held firmly in its new position by chemical forces, served to preserve exactly the structural appearance of the animal or plant. Thousands of species of animals and plants have been found in a fossillized state in the stratified rock deposits. They begin with the oldest of our formations and continue to the latest. Thousands of distinct species have been found in a fossilized state, but tens of thousands of species, perhaps, have perished—wholly decomposed—and left no trace of having existed, further than that which is found as residual oil or gas. In the breaking up of organic matter under the natural process of decomposition, a considerable proportion of oil and gas is the result. The process of nature is disintegration, decomposition, complete separation into elements; the elements enter at once into new combinations, new compounds, new forms of plant life, new forms of animal life; death, decay and dissolution again, and so the round continues.

Oil (petroleum) and natural gas are the imprisoned elements of decomposed organic bodies. If organic bodies decompose upon the surface, or in shallow water, complete dissolution takes place. Tissue and fiber of every kind, every portion of the body except the mineral matter, is resolved into gas, escapes into the air and is distributed over the surface of the earth. Precipitated by the rainfall or other forces, it mixes with the soil again, is absorbed by the plant again, the plant is eaten by the animal, which in the course of nature dies, decomposes, and the elements are freed again in the form of gas, to go the round again and again. But, where organic bodies perished and were buried under conditions that did not permit immediate decomposition, where they were buried under accumulations of sediment in seas, lakes or lagoons, and shut off from the air—hermetically sealed, as it were—decomposition was not completed for ages. The accumulated super-lying deposits excluded the air and prevented complete decomposition. If decomposition was complete the petroleum would all be resolved into gas, for gas is near the ultimate limit of nature's analytical work. Where organic bodies decomposed slowly, under heavy accumulations of sediment, decomposition was not perfect.

The oil (petroleum) was not all resolved into gas, nor was the generated gas permitted to escape. The super-lying accumulations formed an impenetrable covering, confining both oil and gas to their original horizon.

As before stated, petroleum and gas are but the imprisoned elements of decomposed organic bodies. They are the result of chemical decomposition by Nature's ordinary process, hence we find both oil and gas throughout all formations of sedimentary rocks. Under favorable conditions decomposition is very rapid; under other conditions it is inconceivably slow. Organic bodies, whether animal or vegetable, buried far beneath the surface, where the air is almost wholly excluded, remain in an unchanged condition for almost infinite periods of time. For example, it is no unusual thing to find trunks of trees, or even the branches, twigs and leaves of plants, a hundred or more feet beneath the surface of the drift deposits in Northern Indiana. Though this vegetation has lain in its clayey or sandy matrix, far beneath the surface of the earth for probably thousands of years, much of it is yet in a well-preserved condition, although, by infinitely slow processes, it is surely decomposing—changing into petroleum and gas. Proof of this fact is constantly being produced. Much of this ancient vegetation accumulated around the margins of, and in, the beds of lakes and swamps at the close of the drift period. The surface of the drift area, at the close of the glacial period, consisted of high hills and ridges and low valleys and gorges. In the valleys and gorges, and in and around the swamps and lakes, vegetation with the advance of genial seasons, accumulated in vast quantities. By the erosive force of time the hills and ridges were leveled, the valleys and gorges were filled with the accumulations washed in from the hillsides, and the masses of vegetation were buried beneath the accumulated debris. It is no unusual thing for well-drillers, in Northern Indiana, to strike these buried swamps in drilling wells. At depths varying from thirty to one hundred feet they frequently reach masses of buried vegetation that are from ten to fifteen feet in thickness. In connection with these buried masses of vegetation frequent accumulations of gas are found. Throughout all of Northern Indiana, where there is a considerable depth of glacial deposits, and over a considerable portion of Illinois, in Kansas, Wyoming and other sections, gas is found in varying quantities in the drift. In many localities wells of considerable volume have been found. This is notably the case in some portions of Illinois, Kansas and Wyoming. The gas is usually found immediately upon reaching the ancient swamp bed, or its horizon. The strongest flows are obtained from the strata of sand that formed the margins of ancient lakes or swamps, and which form perfect reservoirs for the gas. Beneath the swamp beds and sand margins of the lake beds, there are usually thick layers of blue clay, which are compact and wholly impervious to gas, oil or water. There is no evidence in any instance that these accumulations of gas in the drift have been derived from any other source than the decomposition of the vegetable matter that was buried in the ancient swamp beds. In every instance that has come under my observation, the drift reservoir is one of very limited extent—a mere "pocket" that is soon exhausted. In some instances the flow is quite strong at first, but diminishes rapidly, and soon seems to cease altogether. But it often occurs that after the gas seems to be wholly exhausted in these wells, slight flows are noticed occurring at irregular intervals, as though the process of generation is still going on. It is certainly quite true, in these instances, that after the first flow of gas has apparently exhausted the well, and subsequent slight flows occur, that the later flow is an accumulation from the continued decomposition of the buried vegetable matter.

The gas of the drift deposits is derived from the decomposition of buried vegetable matter. Much of this buried matter is not yet wholly decomposed; the process of decomposition under natural processes is still going on, and in the drift area, gas, and probably petroleum, in places, is still being generated. The vegetation from which the gas is derived accumulated upon the margins of, and in small swamps and lakes that were hemmed in by steep hillsides. The gas reservoirs are small, and the supply necessarily limited. As already stated, thick layers of bowlder clay lie below the gas-bearing sands, and as a general thing clay accumulations of varying thickness lie above.

It is quite often assumed, when small pockets of gas are found in the superficial drift deposits, that the gas has escaped from a leak in the rocks below, and that by drilling in the paleozoic rocks the principal reservoir may be found. Frequent attempts have been made, at various points in Indiana, to find the reservoir that was supposed to lie below, but, in every instance, so far, that has come to my knowledge, the efforts have been futile. All the gas confined in the drift has been generated from decomposed organic matter that was buried in the drift deposits.

It will scarcely be denied that the drift gas has had its origin in the manner indicated above. It has been generated by nature's simple, only process—chemical or spontaneous decomposition. The drift gas, to a practical extent, is identical with the Sub-Carboniferous and Trenton gas. Some little difference of environment has changed the chemical qualities to some extent, but virtually there is but little difference between the one and the other. No two contiguous gas wells will produce gas consisting of exactly the same chemical elements, even in the Trenton rocks. There is a difference between the Trenton and the shale gas, and between shale gas and gas from a sandstone reservoir, but the difference is the result of environment, very slight at most, and may not be attributed to method of origin. Possibly, however, gas derived wholly from decomposed animal matter would vary considerably in chemical constituents from gas generated from some form of vegetable matter. However, the question is not one of elements, but of origin, and the conclusion seems forced that the gas of all geological formations has been derived from organic matter, both animal and vegetable, by nature's simple method, spontaneous decomposition.

All the sedimentary rock formations were, during the period in which they were deposited, in exactly the same condition that the bottoms of our existing seas, lakes and lagoons are now. The bottoms of ancient seas and other bodies of water consisted of vast accumulations of sand, of oozy, black accumulations of finer silicious particles, or vast areas of great depth composed of decomposed and decomposing shells; the surface of the shell deposit being composed wholly of masses of living shell fish. Other areas consisted of smaller proportions of shell fish in various conditions, from living animals to the dead, decomposing and wholly decomposed remains, mixed with which were larger or smaller proportions of impurities of various kinds. Those areas where the remains of shell fish accumulated to the exclusion almost of every other kind of material, after the lapse of ages, and under natural processes, hardened into almost pure carbonate of lime. Where mineral impurities, to a greater or less extent, were mixed with the accumulations of decomposing shells, the cemented mass became an impure limestone, magnesian limestone, silicious limestone, argillaceous limestone or shale.

The immense accumulations of sand became sandstone, and the areas of finer silicious deposits, areas where various kinds of mineral matter in the finest state of mechanical separation, with which were sometimes mixed vast amounts of vegetable matter, were the principal deposits, became shales.

The pure limestones are derived almost wholly from the decomposition of organic bodies, of which the bony outside skeleton, the shell, formed by far the larger portion. It is no unusual thing to find layers of limestone several feet in thickness that are composed wholly of fossil shells in a good state of preservation. It is said by anatomists that a bony skeleton consists of mineral and animal matter. The animal matter is the gaseous portion, or the portion that is resolved into gas when decomposition takes place. The skeleton of a shell-fish also consists of mineral and animal matter—the mineral matter forming the larger portion. Aside from its shell, the mollusk contains but a small per cent. of mineral matter—the remainder resolving into gas upon decomposition. The purest limestones, the carbonates, are remarkably free from vegetable remains. The organic forms that entered into their composition were almost, if not wholly, animal. Hence, if a reservoir of gas is found which is confined wholly to a stratum of carbonate of lime, the inference is that the gas confined within it was derived almost exclusively from the decomposition of animal remains. And so with a formation containing remains principally of a vegetable growth. The inference is that the gas from that horizon is derived largely from the decomposed vegetable matter.

Some of the Devonian and other rocks contain a large proportion of bituminous matter, oil and gas, that has evidently been derived in part from the decomposition of cryptogamous plants—the algæ of the sea—and in part from decomposed animal remains. Some of the Devonian shales contain both animal and vegetable remains in large quantities.

Petroleum and gas, being confined exclusively to the sedimentary rocks, have certainly originated in the rocks that confine them. Organic matter contains all the elements of petroleum and gas. All stratified rocks contain greater or less quantities of organic remains. Since organic bodies are known to possess all the elements of petroleum and gas, and since it is known that petroleum and gas are confined to those rocks that contain organic remains, the conclusion is forced that the gas and oil have been derived from the decomposition of organic matter.

After concluding that petroleum and gas have been derived from decomposed organic matter, and recognizing the fact that all stratified deposits contain organic remains, the question arises: Why may not gas and oil be found in all the sedimentary deposits? Or why may not oil and gas be found in one portion of the Trenton rock as well as another? It is probably true that about as much gas was generated in one locality as another, and in one horizon as another; but the gas in different horizons was generated under different conditions. In those localities where little or no gas is found in the rocks, the probability is that the organic matter deposited with the material that forms the rocks decomposed about as fast as it was deposited, and the gas escaped as fast as decomposition took place. At those localities where gas is found in paying quantities the accumulations of sediment deposited with the organic bodies was sufficient to bury the matter before decomposition took place, and sufficiently heavy when decomposition did occur to confine the gas, and, to a certain extent, to prevent, or to retard for a long period, at least, the complete analytical work of nature. The petroleum, distributed largely through all the sedimentary rocks, having an origin common with gas, is but a residual portion of organic matter that is still undergoing a change from a compound to the simplest state of nature. Wherever petroleum exists in the rocks, the process of decomposition is still going on; the oil is being slowly but continually resolved into gas.

While it is a recognized fact that the limestones form the reservoir in which the gas in the great Indiana field is confined, it is highly probable that the greater proportion of it, by far, was derived from the super-lying black shale of the Utica group. These shales, as a rule, are highly bituminous, and are probably not only the source of the gas in the Trenton rocks, but the petroleum as well.

Along the Ohio River, in Harrison County, Indiana, and more especially along the opposite side of the Ohio River, in Meade County, Kentucky, there are about thirty wells producing gas in quantities varying from a few thousand to four millions or more cubic feet per day, and all the gas is derived directly from the Devonian black shales. The shales, themselves, form the reservoir. These shales, of course, are not crystallized and porous, like the limestones, but they consist of innumerable, slate-like layers, and the gas is confined in the spaces between the layers. On account of these structural features of the shales, shooting the wells in this region has not been productive of satisfactory results. As a rule, the flow of gas has not been increased by the explosion.

The fact, that in this region the gas is confined wholly to the shales, leads strongly to the conclusion that it has had its origin in the immediate reservoir that confines it, more especially since these shales are known, at every point of exposure, to be highly bituminous.

PERMANENCY OF THE GAS SUPPLY.

The thing next in importance to securing natural gas in available quantities is to secure a permanent supply, and perhaps no question is more frequently asked concerning gas than this: "Will the supply be permanent—will it last?" No means are at hand yet to determine this matter. The extent of the reservoirs is not absolutely known. The porous rock, however, that forms the reservoir is known to be but a few inches thick in some localities, and to be as much as twenty-five or thirty feet thick in other places. In undeveloped places the porous stratum may even exceed thirty feet in thickness. If the generation of gas is not going on at the present time at a sufficiently rapid rate to keep up the initial pressure in the reservoirs, then the supply will be exhausted after a time. In the older rocks petroleum is undoubtedly the only source from which gas is being derived at the present time. There can be no doubt of this. It has been shown to some extent, in the discussion of the origin of gas, that both substances, petroleum and gas, are intimately associated together in the rocks, and that they have a common origin. The process of decomposition is never completed until the elements that enter the structure of organic bodies are resolved into their simplest form. Petroleum is a residual portion of organic matter confined in the laboratory of Nature upon which the disintegrating forces are still operating. The work of nature, in this particular, is not yet complete, and will not be until all the petroleum distributed through the rocks is resolved into gas. While this work is still going on, the stock of gas upon which enormous draughts are made, and which are likely to be increasing for a considerable length of time, will be, to a certain extent, replenished. But it is not at all probable that the amount of gas generated from petroleum will nearly equal the quantity drawn from the reservoirs by artificial means. Indeed, it is highly probable that the natural waste of gas is greatly in excess of the amount generated from all sources. There is a tendency of the gas to expand to extreme tenuity. There is a repulsive force operating upon the molecules of matter in a gaseous form that tends to produce the most extreme subtilty in this fluid. It is this repulsive force, this tendency of the gas to expand to almost unlimited extent, that forces it out through the minute interstices—the pores of the rocks. It acts upward and downward, and in every direction with exactly the same energy. This force is sufficient to carry the gas out through the rock in every direction, and the expansion is only limited when an area of wholly impervious rock is reached. Where there are fissures in the rock extending from the gas reservoir to the surface, or where the porous rocks extend to the surface, the gas finds its way to the atmosphere, where it is immediately dissipated. It is this same tendency of gas to expand that gives it a force sufficient to lift several hundred pounds per square inch. Confined in its reservoir of rock the gas is compressed to an enormous extent. There is no means of determining the capacity of the interstices of a cubic foot of porous rock that forms the gas reservoir. When the exact limits of a gas area are known, and when the average thickness of the porous rock is known, the capacity of a gas reservoir may be estimated to an approximate degree, but it will never be possible to estimate to any satisfactory extent, the capacity of the interstices that contain the gas. If it was known just how many cubic inches of gas in its compressed state there are in a cubic foot of porous rock, and if it was known, too, just how many cubic feet of gas those cubic inches are equal to, reduced to atmospheric pressure, then we could determine, approximately, how many thousand of millions of cubic feet of gas there are in a reservoir.

The statement is frequently made by writers in newspapers that the natural tendency of oil and water is to move downward, and of gas to move upward in the rocks. This statement is not in a strict sense correct. The tendency of gas and every other substance is downward, in the direction of the center of the earth, in obedience to the law of gravitation. The tendency of gas is to expand equally in all directions until complete separation of elements is attained. When gas is brought to the surface and comes in contact with the atmosphere it moves upward, but not because there is a natural tendency in the gas to do so, but because there is a law which draws the air, a heavier substance downward. The atmosphere displaces the gas and lifts it upward, just as a piece of cork is lifted to the surface when sunk to the bottom of a tank of water. There is no tendency on the part of a piece of cork to rise in water, but the law of gravity draws the water, which is the heavier substance in proportion to its bulk, downward, and the cork is lifted by the water. Cork will not remain suspended in the air for the reason that it is heavier in proportion to volume than air. Air is heavier in proportion to volume than gas, consequently the latter is lifted by the former. There is no tendency of the gas to move upward farther than that produced by the law of expansion.

An idea prevails, to some extent, that when gas escapes to the atmosphere it is carried upward, and being lighter than air, it remains forever afloat on the surface of the heavier substance, and is wholly lost to the earth. It is more probably true that the gas is carried to an altitude where the tenuity of the air equals or exceeds that of the gas; to an altitude where the point of ultimate expansion may be attained. At this elevation complete separation of elements takes place, and the particles fall back to the earth again as simple, ultimate atoms.

It is certainly true that all gas reservoirs, upon which draughts are made, will be wholly exhausted after a time. Whether that time will be extended to a long period, or limited to a few years, is yet to be determined. Even if the generation of gas from petroleum is equal to the natural and artificial waste, the supply of gas is certain to be exhausted at some period, for the stock of petroleum will be entirely dissipated after a time. But the probabilities are that the amount of gas being generated in the rocks from all sources is inconsiderable in comparison with the enormous quantities that are drawn off by natural and artificial agencies.

No satisfactory method of ascertaining the amount of gas stored in nature's reservoirs has yet been suggested. I think, however, that by a series of carefully made experiments, continued through several months of time, that it is possible to determine approximately how long gas may be secured in paying quantities. Assuming that the Trenton rock gas area of Indiana consists of one vast connected reservoir, which is evidently true, these experiments should be made at several different points at the same time, say, for instance, at Kokomo, Noblesville, Marion, Anderson, Greenfield, Muncie and Portland. If the initial pressure of the gas is accurately ascertained at one of the average wells at each of these points, at the same time, say September 1st, and the pressure of each of these wells is accurately taken again in three months, and once every three months thereafter for a considerable period of time, it can be ascertained to a certainty whether the initial or rock pressure is diminishing any or not, and exactly to what extent. Also, at the time the initial pressure is taken, the volume of gas escaping from the wells should be accurately measured. A series of such experiments will determine whether the amount of gas flowing from the wells is diminishing or not, and, if so, to what extent. Such measurements willl give the ratio of decrease both in initial pressure and volume of gas. Having the ratio of decrease, an approximate estimate of the durability of the wells can readily be made.

Since it is altogether probable that the Trenton rock gas area of Indiana is one vast, connected reservoir, containing, possibly, more than 4,000 square miles, the stores of natural gas contained within it must be enormous; certainly enough, if used economically, to last the population for many years. But the certainty that the supply will be exhausted after a time, however remote that may be, must be clearly apparent to any one who has given the subject any careful thought.

The importance, then, of husbanding the supplies and guarding carefully against any unnecessary waste ought certainly to be appreciated by all. One million cubic feet of gas is worth one hundred dollars in gold. For the past six months there has been an average waste of about 100,000,000 cubic feet of gas per day in Indiana.* This is worth $10,000 in currency or coin. The volume of gas wasted in the last six months is not less than 15,000,000,000 cubic feet, worth $1,500,000. Is not such extravagance wrong? Is it not foolish? Many of the wells have been thrown wide open and the gas allowed to burn as an advertisement. Is not such advertising too costly? No operator would think of setting fire to his coal mine merely as an advertisement, and yet the volume of gas escaping from an average well in Indiana is equal to 250 tons of coal per day for heating purposes. The daily flow from an average gas well in this State, at a coal value, is worth $625 Can a city or town afford to pay $625 per day for advertising?

Whenever a well is drilled into Trenton rock, or any other rock containing gas, and a satisfactory flow is obtained, it should be immediately packed and securely capped in. If it is an average well it is worth to the consumers six hundred dollars per day. To the owner it is stored wealth which he is certain to realize at no remote period. If it is allowed to flow out and burn or waste for six weeks, it is worth $25,000 less to the owner, for that is the value of the gas that will escape in that length of time.

The fact that Indiana has an enormous reservoir of natural gas is everywhere recognized at the present time. There is not an intelligent manufacturer nor other well-informed citizen in the United States that is not aware of it. The enormous flame produced by a well yielding 5,000,000 cubic feet of gas per day is a great advertisement of the capacity of the well, but the intelligent manufacturer or capitalist who views the monstrous flame, and is informed that it has been burning with undiminished vigor for a month, mentally calculates that in that length of time $15,000 worth of gas has been consumed, consequently the amount of gas that can be delivered to the consumers from it is diminished to the value of $15,000.

If used economically the supply of gas is not likely to be exhausted for years to come, but it is certain that the entire accumulation will fail sooner or later. Extravagant waste, therefore, is foolish and criminal.

The foregoing chapter on the permanency of the gas supply was written in November, 1887. The developments of the past year have established the fact that the supply of gas is gradually diminishing in all the wells. This is not noticeable as yet, perhaps, in the stronger wells, since no accurate methods have been used to determine the facts, but in many of

* This part of the Report was written in November, 1887.

the smaller wells the volume of gas produced daily has greatly diminished. I have data at hand, which, perhaps, need not be published in detail here, but which show positively that the volume of gas produced daily, not only in the wells of Indiana, but in those of Ohio and Pennsylvania also, is gradually diminishing. And while, in most instances, the volume of gas is not diminishing at a sufficiently rapid rate to produce immeditae alarm on account of the apprehension of an early exhaustion of the supply, the fact is clearly apparent that the entire supply of gas in the present fields, if the present degree of consumption and waste is continued, will become wholly exhausted in a few years. It is important, therefore, that great care should be exercised in husbanding the supply, and economy should be practiced in the use of it.

At this time, as this report goes to press, the large wells have all been closed in and the gas confined, but there are yet many small wells which the owners have not deemed it worth while to cap nor confine, and the gas flowing out of them is assisting in the gradual exhaustion of the entire field. The average daily waste at this time probably approximates 10,000,000 cubic feet. If possible, legislative enactment should compel the owners to securely cap all wells, and properly confine the gas within a reasonable length of time after they are drilled. Since the Indiana gas area evidently consists of one vast, connected reservoir, it is undoubtedly true that a single well, in time, would exhaust the entire field. It is true that the fee simple of land entitles the owner to all the minerals or other substance that lie beneath the surface, to whatever distance he may penetrate, and none may question his rights, but if his lands adjoin a lake of water around which other farms are situated, and upon which other farmers depend for water, he has no right, in law, to drain the lake, even if the ditching may all be done upon his own land, and thus deprive the joint owners of their rights. And so no one should be allowed to wastefully drain the great gas reservoir, which is common to all, for the reason that he not only exhausts the reservoir situated under his own land, but that under his neighbors' land also.

It occurs to me that a law might be enacted that would deprive no individual of his rights in the legitimate use and sale of gas, but would, at the same time, restrain him in the extravagant use and waste of it.

THE ANTICLINAL THEORY.

All the largely productive gas areas, so far developed, lie in regions of ancient disturbance. This is true of the Pennsylvania and Ohio fields, and Indiana also. Wherever these disturbances occur they usually appear as long, elevated ridges with intervening troughs or valleys. The arches, or ridges, are termed anticlines and the troughs synclines. Throughout the Indiana gas area the accumulations of foreign material transported to this region during the glacial period, have covered, to a large extent, the sedimentary rock deposits, and but few exposures remain at which examinations can be made. However, along the Wabash, Salamonie and Mississinewa Rivers, and other streams, the exposures are frequent enough to permit satisfactory examinations. To any one who will take the trouble to examine the rock exposures along the Wabash River and other streams in that region, the fact will at once be manifested that a series of disturbances extends entirely across the State of Indiana, which, in a general way, follow a northwest and southeast course. This area of disturbance consists of a broad arch in the western part of the State, while in the eastern portion it spreads out into a wide table-land. The eastern portion of the arch, the table-land, is the area in which the natural gas reservoir occurs.

Concerning the connection of anticlines with the accumulation of natural gas, in areas affected by slight upheavals, Prof. I. C. White, of the U. S. Geological Survey, who first presented the anticlinal theory to the public, in a paper published in *Science* for June 26, 1885, says:

"The writer's study of this subject began in June, 1883, when he was employed by Pittsburgh parties to make a general investigation of the natural gas question, with the special object of determining whether or not it was possible to predict the presence of gas from geological structure. In the prosecution of this work I was aided by a suggestion from Mr. William N. Earsman, of Allegheny, Pa., an oil operator of many years' experience, who had noticed that the principal wells then known in Western Pennsylvania were situated close to where anticlinal axes were drawn on the geological maps. From this he inferred there must be some connection between the gas wells and the anticlines. After visiting all the great gas wells that had been struck in Western Pennsylvania and West Virginia, and carefully examining the geological surroundings of each, I found that every one of them was situated either directly on, or near, the crown of an anticlinal axis, while wells that had been bored in the synclines on either side furnished little or no gas, but in many places large quantities of salt water. Further observation showed that the gas wells were confined to a narrow belt, only one-fourth to one mile wide, along the crest of the anticlinal folds. These facts seemed to connect the gas territory unmistakably with the disturbance in the rocks caused by their upheaval into arches, but the crucial test was yet to be made in the actual location of good gas territory on this theory. During the last two years I have submitted it to all manner of tests, both in locating and condemning gas territory, and the general result has been to confirm the anticlinal theory beyond a reasonable doubt.

"But while we can state with confidence that all *great gas wells* are found on the anticlinal axes, the converse of this is not true, viz: that *great gas wells* may be found on all *anticlinals*. In a theory of this kind, the *limitations* become quite as important as, or even more so than the theory itself, and hence I have given considerable thought to this side of the question, having formulated them into three or four general rules (which include practically all the limitations known to me, up to the present time, that should be placed on the statement that large gas wells may be obtained on anticlinal folds), viz:

"(*a*) The arch in the rocks must be of considerable magnitude. * * *

"(*b*) Very fair gas wells may also be obtained for a considerable distance down the slope from the crest of the anticlinals, provided the dip be sufficiently rapid, and especially if it be irregular or interrupted with slight crumples. And even in regions where there are no anticlinals, if the dip be somewhat rapid and irregular, rather large gas wells may occasionally be found, if all the other conditions be favorable. * * *

"The reason why natural gas should collect under the arches of the rocks is sufficiently plain, from a consideration of its volatile nature. Then, too, the extensive fissuring of the rocks, which appears necessary to form a reservoir for a large gas well, would take place most readily along the anticlinals, where the tension in bending would be greatest."

The foregoing quotation from Prof. White is a brief statement of the anticlinal theory. The stratified rocks, which were originally deposited in a nearly level plain, or, at least, with only such irregularities in structure as invariably occur in sea bottoms, either by upheavels from beneath or contraction of the earth's volume, have in many places been wrinkled up. If the corrugations were produced by contraction of the earth, they are certainly wrinkles. These wrinkles consist of a series of arches (anticlines) and grooves (synclines). Where the wrinkles appear in the surface deposits, it is known that they continue downward through all the sedimentary rocks. The surface of the rocks is generally covered by accumulations of transported material or the local residum of disintegrated and decomposed rocks, so that examinations have usually to be made along the streams where the erosions have denuded the rocks. Bluff escarpments frequently show exactly the amount and direction of the dip.

Where disturbances have produced low folds in the strata, and have not been sufficient to totally upheave the rocks and fracture them so as to permit the gas to escape, the effect upon the position of the fluids confined in the strata is supposed to be quite marked. The average thickness of the porous, gas-bearing stratum of Trenton rock in Indiana is in the neighborhood of twelve feet. This rock in some localities contains gas, oil and salt water. If the stratum was lying in a horizontal position the water would naturally settle to the bottom of the porous rock, and the interstices of the lower part of it would contain nothing but water. The petroleum, which is lighter than water, would fill the interstices in the rock just above the salt water, and gas would occupy the upper portion of the stratum, being lighter than either water or oil.

Now, what would be the effect upon the relative position of the substances, gas, oil and water, if by the contraction of the earth's volume or upheaval, or other force, the strata were forced into a series of wrinkles or corrugations? Manifestly the water would work its way down the inclines and fill the lower portion of the synclines or troughs. The oil would finally adjust itself to a position just above the water in the syncline, or along the slope of the anticline, and the gas would occupy the summit of the anticline. This would all probably occur where a stratum of porous rock was wholly filled with salt water, petroleum and compressed gas. While the disturbance that affected the position of the rocks in the Indiana gas area undoubtedly date back to the close of the Niagara period, it is evidently true that the generation and accumulation of petroleum and gas in the Trenton antedates even the formation of the Niagara rocks by ages. The petroleum and gas were probably generated long before the beginning of the Niagara period, hence the disturbances that affect the structure of all the strata at the close of the Niagara period had no agency in the generation nor accumulation of the Trenton gas. But the change of structural conditions, affected by the disturbance, had the effect of modifying the relative position of the various fluids confined in the rock reservoirs. Water, the heaviest fluid, occupied the trough; gas, the lighter, accumulated in the arches, and the oil was forced into the intermediate position. The facts developed in Indiana, though not wholly conclusive, are largely corroborative of this view. Where the disturbances were of such a nature as to wholly upheave the strata, or to fracture them to a great extent, as was the result along the Wabash River, the gas escaped to the atmosphere and was at once dissipated.

It does not, as a necessity, follow that gas will be in all arches, nor that water will be in all synclines, but where the porous stratum, before the disturbance occurred, contained gas, petroleum and water, the different substances will be found occupying positions relatively as stated. Where no water is present, the oil, if any, will occupy the syncline. If neither water nor oil is present, then the gas will permeate every portion of the porous rock, syncline as well as anticline, and the pressure will be just as strong, and, other things being equal, the flow will be just as great from a syncline as from an anticline. In areas where the organic remains decomposed as fast as deposited the gas escaped as it was generated; hence, however favorable the structural conditions may be, no gas is to be found in such rock. This is the case, usually, where areas occur in which the limestones are nearly pure carbonate. There was no accumulation of transported sediment sufficient to bury the organic remains deep enough to prevent immediate decomposition, nor to confine the gas. Strata, consisting largely of carbonate of lime, have, so far, yielded but small supplies of gas.

As a rule, the larger supplies of gas are found in anticlinals in this State, though by no means is it to be found, always, in the higher Trenton rocks.

A practical application of the anticlinical theory, in the location of gas wells, may result greatly to the advantage of the explorer, will surely do so if the theory is true, and, in any event, I can not see that any harm can result from prosecuting the work on the supposition that the theory is true. The boring of a gas well, in undeveloped territory, is largely an experiment at the best; and, inasmuch as it is confidently asserted by some experienced, practical geologists, who have given the subject the most thorough investigation, that where gas is contained in a reservoir, the largest accumulation invariably occurs in the anticlinals, prudence should dictate the location of a gas well on an arch.

The accumulations of drift are usually so great throughout the Indiana gas area, that, as a rule, it is impossible to determine the location of an arch in advance of drilling. The anticlines, in a general way, have a northerly and southerly direction, but in many instances they go zigzagging in various directions. It is also quite probable that throughout the Indiana gas area there are many rounded cone-like elevations of the strata, more like a hill than a continuous arch. These elevations would, of course, be governed by the same conditions that prevail in the arches. The larger flows of gas might be expected from the crown, or summit of the elevation.

Opinions, similar to those entertained by Prof. White, are entertained by many eminent, practical geologists, men who have investigated the subject in a practical way most thoroughly; while a number of others, equally prominent in the profession, are of the opinion that practically the anticlinal theory possesses no importance whatever. The discussions of the geologists are important in this, they tend to more thorough investigations of the subject, and a final development of the truth.

THE SEA LEVEL THEORY.

In the productive gas area of Indiana the Trenton rocks are found at geographical horizons varying from 158 feet above sea level to 1,072 feet below it. The higher level is at Lawrenceburg, in Dearborn County, and the lower one at Auburn, Dekalb County. The largest well drilled at Lawrenceburg to date flows 1,240,000 cubic feet of gas per day, while the best well at Auburn produces probably not less than 2,000,000 cubic feet per day. The Trenton limestone, in all the larger producing wells of the State, is found at a horizon varying from sixty to seventy feet above sea level to 110 feet below, except at Lawrenceburg, where, as stated, it is 153 feet above, and at Auburn and other points in Dekalb County, where it is from 1,050 to 1,200 feet below sea level. In the great gas wells of the Ohio field, Trenton rock is found at from 300 to 400 feet below sea level. In Ohio the geographical oil horizon lies a little below that of the gas, and the salt-water horizon is just below the oil. As yet no great gas reservoir has been found in the Trenton limestones where these rocks lie at a greater depth than 1,200 feet below sea level. Gas has been found at many points, both in Ohio and Indiana, at greater depths than 500 feet below sea level, but none of the wells are of the first nor even the second class, perhaps, except those at Auburn and vicinity. At well No. 1, Ft. Wayne, Trenton rock was found at a depth of 693 feet below sea level. A sufficient amount of gas was obtained from this well to run the engine for drilling well No. 3, when piped about one-half mile. The initial pressure of the well is 160 pounds. Gas and oil both have been found at Bryan, Williams County, Ohio, where the Trenton limestone is found at about 1,200 feet below sea level. In well No. 3 the gas was found at a depth of 2,035 feet, and the drilling continued to the depth of 2,092 feet.

Prof. Orton, of Ohio, has entertained the opinion that neither gas nor oil would be found in paying quantities at greater depths than 500 feet below sea level. If he is correct in this view, which is generally referred to as "The Sea Level Theory," for the field at Auburn may be a single exception, a great deal of money may be saved by first obtaining a knowledge of the geology of a locality in which it is proposed to bore a well.

An examination of the evidence upon which this theory is founded shows that it is wholly of a negative character, the same kind of evidence precisely upon which was founded the opinion which prevailed among geologists a few years ago, that neither gas nor oil were likely to be found in paying quantities in the Trenton rocks. When gas and oil were actually found in large quantities in the Trenton rocks the facts were accepted and the theory abandoned. When gas was found in the Trenton rocks geologists readily accounted for its presence there, for it was undoubtedly derived from the decomposition of organic matter deposited with the sediment that formed the Trenton limestones or the overlying shales. All admit now that there is gas in the Trenton rocks, and there is a general agreement upon its origin. Since it is known that these rocks contain gas and oil, and the origin of these substances seems plain, is there any reason why they should be limited to any particular geographical horizon?

It does not occur to me that structural disturbances assisted in any way in the generation of gas. The disturbances that affected the strata of Ohio and Indiana occurred long ages after the accumulation of gas and oil in the Trenton rocks. The effect of the disturbances was to increase the capacity of the reservoir in some places and diminish it in others. Water flowing into the synclines expelled the gas from them and forced it into the anticlines; but the elevation of an area, like the Indiana plateau, did not affect the accumulation of the gas in a general way. The gas confined in the rocks accumulated there while they were in their original position—before any disturbance took place. The Trenton rocks of the Indiana gas area have been elevated above their original position from one hundred to three hundred feet. The gas reservoir, with its confined gas, was raised with them. Had the disturbance never occurred, the gas would still be retained in the rocks. Along the Wabash River, near the northern rim of the reservoir, the disturbances were of such a nature as to fracture the strata greatly, and tilt them to various angles, thus permitting the gas to escape. The evidence is clear that the accumulations of gas along the Wabash River escaped through the numerous fissures in the rocks ages ago. If the Trenton rocks of Indiana and Ohio were all lying in their original position, whether that was one hundred or one thousand feet below sea level, the gas would still be confined within them.

The conditions that prevailed at the time the organic matter was deposited from which the gas was derived are the only ones that affect gas accumulations. If the matter decomposed as fast as it was deposited, the gas was immediately dissipated. Wherever the sediment accumulated above it sufficiently to prevent immediate decomposition, the gas was generated by slow degrees, and is yet confined in the rocks, except in localities where local disturbances have fractured the strata, and permitted it to escape.

The gas horizon of Indiana, varying from one hundred feet above to twelve hundred feet below sea level, and that of Ohio varying from three to four hundred feet below sea level, are mere accidents of structure which in no way affected the generation, nor general accumulations of gas and oil. It is possible, of course, that gas may rarely be found in large quantities at greater depth than five hundred feet below sea level, but the cause must be attributed to other conditions than the structural features. Organic matter formed a portion of the sediment throughout the entire extent of the Trenton limestones, and, indeed, all other limestones. The author of the "Sea Level Theory" is among those geologists who agree in the conclusion that gas and petroleum are derived from decomposed organic matter. Since it is well known that vast amounts of organic matter were distributed through nearly every portion of the Trenton rocks, why is it not as likely that gas may be found in that formation one thousand feet below sea level as that it may be found at from one hundred to five hundred feet below? The rock assumed its crystalline, porous structure when the gas was generated. No subsequent structural changes ever occured to create the crystals and interstices. The decomposition of the organic matter, the generation of petroleum and gas, and the crystallization of the rock, all occurred at the same time. Gas and petroleum could not have remained in the rock without the interstices to contain them, nor could the decomposition of matter have taken place after the crystallization and perfection of the rock. The Indiana plateau and the Ohio plateau are structural features that came into existence long after the gas had accumulated in the Trenton rocks. May there not be other areas, then, where structural disturbances never occurred to a great extent, where large quantities of gas may yet be found in the Trenton rocks, even though the deposit may lie one thousand feet or more below sea level? Or may it not be found in other formations of sedimentary rocks, where they lie one thousand or two thousand feet above the level of the sea?

The fact that the surface of the Trenton limestone in the Indiana gas area lies from one hundred feet above sea level to twelve hundred feet below it, and that the surface of the same formation throughout the Ohio gas area lies from three hundred to four hundred feet below sea level, is a fact of coincidence merely, and not one that is related in any way to the generation nor accumulation of gas. The conditions that prevailed at the time the rock material was accumulating at the sea bottom, and those alone, affected the gas and petroleum accumulations. Wherever the conditions were favorable for the rapid decomposition of matter, the gas all escaped; but, where the accumulations of mineral matter were sufficient to cover the organic bodies completely, decomposition was slow, and much, if not all, the gas is yet confined in the rocks.

The horizon of salt-water is as variable as that of the gas and oil. At Tipton, Ind., salt-water was found at a depth of thirty-three feet in Trenton rock—one hundred and sixty feet below sea level; at South Bend salt-water was found at a depth of about a thousand feet below sea level in the same rocks. Ocean level does not in the least affect the vertical distribution of water, oil nor gas. The salt-water, the brine, found in the Indiana rocks is confined in local pools or reservoirs, and is not generally distributed. Wells have frequently been bored to the depth of one thousand feet, or more, below sea level, in this State, without finding it. It is an element that certainly does not affect the gas accumulations in this State to any measurable extent, though in some localities it is likely that the gas is slightly compressed by hydrostatic pressure.

Gas and petroleum are found only in the sedimentary rocks. They were derived from the decomposition of organic matter that was buried with the sediment that forms those rocks. They are not confined to any particular geological nor geographical horizon. The only conditions which governed the accumulation of these substances were those that prevailed at the time the rocks were forming.

The finding of gas at a particular horizon at one point in Indiana does not prove that it will be found where the same rocks approach the same horizon at another point. Neither does it prove that gas will not be found at places where the same rocks are reached at an altitude one thousand feet lower.

CONTRACTING FOR WELLS.

By far the larger proportion of the wells drilled for gas and oil in Indiana have been drilled under the direction of local stock companies. As a general thing the Board of Directors, acting for the company, has contracted with a practical workman, who is to drill a well to a certain depth, or to a certain depth in Trenton rock, for a specified sum of money. It s quite often the case that the contract between the parties is so indefinite in its terms that serious misunderstandings arise, and serious controversies, and sometimes lawsuits, are the result. All contracts should be so explicit in their terms as to be readily understood, and to admit of no misconstruction. Before a well is drilled it should be ascertained as nearly as possible how far it is to Trenton rock, or any other rock that it is desired to penetrate, and the contract made for a specified depth, with a provision to continue the drilling to a greater depth, at a specified price per foot.

In several instances serious trouble has arisen where the contract required that the well should be drilled to a fixed number of feet, or fifty feet into Trenton rock. In these instances the trouble grew out of difference of opinion as to the identity of the strata passed through. The contractors claimed that their contract was complete when Trenton rock was reached, and a mistake in the identity of the strata by one party or the other caused the trouble.

In one instance in the northern part of this State, a contract required the well to be drilled 1,600 feet, or fifty feet into Trenton rock. At the depth of 550 feet the contractor claimed that he had struck Trenton rock. He continued the well to the depth of 615 feet, and then stopped, claiming that he had completed the contract. A serious controversy arose which was not settled for several weeks, and resulted in a great loss to both the company and contractor. In this instance the contractor was mistaken, for the bottom of the well at 615 feet was just 1,200 above the Trenton rocks.

Another instance, to still further illustrate, occurred rather in the southeastern part of the State. In this case the well was to be drilled fifty feet into Trenton rock. Trenton rock was found at 550 feet, but the company failed to identify it, and compelled the contractor to go nearly a hundred feet deeper, after he had actually completed his contract.

Many other instances might be mentioned where serious losses have been sustained by one party or the other, or both, on account of defective contracts.

There is no occasion for contracting to have a well drilled fifty feet into Trenton rock. The approximate depth to Trenton rock may be easily ascertained in any county in the State. Where a company determines to have a well drilled, they should ascertain, as nearly as possible, the depth to the rock they wish to reach. Then contract for the well to be drilled to that depth for a fixed sum, with a provision that if it is desired to continue the drilling to a greater depth, it shall be done at a specified price per foot.

It frequently occurs that trouble arises over the ownership of the casing and drive-pipes that are used in the construction of a well. It is usually understood that if the well proves to be a paying one, that is, if it yields gas sufficient to justify piping, the drive-pipe and the casings become the property of the company, otherwise, they may be retained by the contractor. Several wells have been drilled in this State from which a very small flow of gas was obtained, so small, indeed, that it could hardly be determined whether it would pay to lay the pipes and incur the other expenses necessary to put it in use or not. The indefinite terms of the contracts, in many of these cases, have caused aggravating disputes, and, in a few instances, law suits. All these disagreeable complications may be avoided if the parties to the contract will take the pains to have a complete understanding beforehand.

Drive-pipe is necessary in the construction of a well. It is the large pipe, usually eight inch, that is driven down through the surface soils, gravel and clays, to protect the well against accidents of caving in, etc. Wherever drift accumulations occur, drive-pipe is absolutely essential, and it must extend down to the solid rock. If the well is started on solid rock, drive-pipe is unnecessary. As drive-pipe costs from $1.40 to $1.50 per lineal foot, and the amount required to thoroughly protect the wells throughout the drift area of Indiana varies from a few feet to four hundred feet, or more, it becomes an item of considerable importance to both the driller and the company. In every case it should be definitely settled beforehand who is to retain possession of the drive-pipe. If the well should prove to be wholly unprofitable, of course the company do not need it, and the driller can readily pull it out and use it again. Perhaps the better way is for the contractor to furnish all his own materials in drillling a well, and, in the event that the company desire to use the well, they should pay him a reasonable price, previously agreed upon, for both drive-pipe and casing.

The casing, usually 5⅝ inches in diameter, is the pipe that is put down inside the drive-pipe, and extended through the limestones or water-bearing rocks, to shut off the water. It can not be determined positively beforehand how much casing will be required.

In the southeastern part of Indiana but very little is necessary, but in the northern part of the State 1,200 or 1,300 feet has sometimes been required. The cost of 5⅝ inch casing is from fifty to sixty cents per lineal foot. When a great amount of it is used the cost is considerable. The casing, like the drive-pipe, is useless to the company if the well is not profitable, while the contractor can readily draw it out and use it again.

Another source of disputes is the work of packing and anchoring the well after securing a profitable supply of gas. When Trenton rock has been reached, and gas in paying quantities obtained, it is necessary that the well should be properly packed and securely anchored. The packing, as it is termed, is the process of confining the gas in a pipe of convenient size from which it may be conducted to the mains for use.

Packing pipes of sizes varying from one inch to four inches in diameter are used. The size of the packing pipe is governed by the productiveness of the well. This pipe is put down inside of the casing, and extended to the gas reservoir. The packer, a device usually made of rubber, is placed around the pipe just at the bottom of the shales, and so adjusted as to completely shut of the gas from the outside of the pipe, thus securing the well against any waste.

Anchoring is the process of securing the packing pipe, or the casing, if no other pipe is used, so that it will not be left out of place by the compressed gas when the well is completely closed. As a rule the drillers consider their contract complete when the required depth is reached, though they sometimes perform the labor of packing and anchoring the well, the company furnishing the materials. It is more frequently the case, however, that the packing and anchoring is done by experts, who devote their time exclusively to that kind of work.

Where the terms of the contract are not explicit, disputes sometimes arise as to who shall incur the expense of packing the well, the company or the contractor. The contractor who has agreed to complete the well, understands that his work is finished when the required depth is reached, while the company understand that it must be packed and anchored—equipped ready for use.

The inconveniences arising from misunderstandings of this kind may all be avoided by a little care in the making of the contract.

A properly constructed contract would require the contractor to furnish all his own machinery, drive-pipe, casing and material of every kind that is used in the drilling of a well. The contract should require that the drive-pipe extend to the solid rock, and that a sufficient amount of casing should be used to thoroughly secure the well against damage by water. It may then be provided that the company may retain the drive-pipe and casing, in case they desire to utilize the well, by paying a specified price for the same. The contract should provide that the company should furnish the pipe and other material for packing the well. As a rule it is better to employ an expert to perform the labor of packing and anchoring the well, but provision should be made for securing the use of the contractor's machinery to perform this work. If it is desired to explode a cartridge of nitro-glycerine in the well, an expert is required for that labor also. The machinery of the contractor will be necessary in the performance of this work also, and provision should be made for its use.

It is better for the contractor to furnish the drive-pipe and casing for the reason that if the well proves to be unprofitable he can remove the same and use it for the construction of another well without sustaining loss. If the company purchase the pipes and the well is a failure, they sustain a loss unless they desire to drill another well.

SURFACE INDICATIONS OF OIL AND GAS.

The experience of the past year or more in Indiana has shown that surface indications of oil or gas, as a rule, are practically valueless. Wherever gas is discovered flowing out through springs of water, either in the drift area or from rock deposits, the fact may be taken as indicating an exhausted reservoir, rather than one from which may be obtained a remunerative supply of gas. Throughout the drift area of Indiana springs frequently occur, from which the gas is continually escaping in small bubbles. If a barrel, or other vessel, is carefully placed over a spring of this kind, and a small pipe inserted into the barrel, the gas may be lighted at the end of the pipe, and it will burn continually. But the amount of escaping gas is so small that it is practically of no value. This drift gas, as a rule, escapes through a sand deposit, that has been cut down into by the erosions of streams of water. The gas was generated in some mass of buried vegetation. The reservoir probably never contained any valuable store, and even if it did at one time contain a considerable accumulation, the waste that has been going on for years has practically exhausted it. Probably the greater amount of gas that escapes through the sand deposits and springs of the drift regions is that which is now being generated from the continued decay of vegetable matter in the buried swamps.

Along the Ohio River and its tributaries, in the southeastern part of the State, where the Hudson River rocks appear at the surface, the springs that flow out of the foot of the bluffs frequently contain a considerable amount of gas, but by no means a sufficient quantity to make it of economic importance. This gas, which had its origin in the Hudson River rocks, is assumed to indicate, in many instances, a large reservoir in the rocks below. But a brief consideration of the matter will certainly convince any one that where there are known to be numerous leaks, in a region where those leaks have evidently been uninterrupted for hundreds, if not thousands of years, the reservoir must certainly be virtually exhausted by this time. The slow generation of gas from the petroleum contained in the rocks may be manifested in the bubbles of gas escaping from springs for scores of years to come, but such manifestations should never be taken as evidence that a great reservoir may be found in the depths below.

Throughout large areas where the Niagara limestones are the surface rocks, the same occurrences of gas leaks are quite common. Also throughout the Niagara exposures it is common to see places where petroleum flows slowly out through fissures in the rocks. In some areas in Indiana petroleum is distributed through the entire mass of Niagara rocks, but it has never yet been found in them collected in a reservoir from which it could be obtained in paying quantities. The Niagara rocks are largely crystalline, in this State, and consequently, porous, so that the gas and oil are permitted to move freely through them. If there ever was any large accumulation of gas in the Niagara rocks, throughout the area where they are exposed, it escaped ages ago. The gas that escapes from them now is evidently that being daily generated from the petroleum contained within them.

A gas leak is a stronger evidence of an exhausted reservoir than *contra.* As already stated, where gas is leaking from the rock or drift deposits of Indiana, at the present time, it must be true that it has been leaking through the same channels, and perhaps hundreds of other channels, for ages, and has thus practically exhausted the reservoir. The gas observed to be leaking from the surface deposits at Findlay, Ohio, before the discovery of the great reservoirs beneath, was certainly not Trenton gas. The drift contains gas, the Niagara and Hudson River rocks contain gas, and the leaking gas at Findlay, Ohio, was evidently from some of these deposits. If the numerous leaks noticed throughout that region had been from the Trenton rocks, the immense reservoir below would have been long ago exhausted. The gas in the Findlay reservoir is wholly confined by impervious rocks. The over-lying Utica shales are two hundred to three hundred feet thick and so close in texture that gas can not permeate them. Just so in the great Indiana field. The gas reservoir here lies below from fifty to four hundred feet of impermeable Utica shales. Unless these shales have been fractured by shrinking of the earth's crust, or upheaval, they are wholly impervious to gas or any other fluid. To obtain gas in paying quantities, it must be completely confined in impervious rocks; and I repeat the statement that gas leaks are not favorable indications of large reservoirs in the immediate vicinity.

A knowledge of the geological formations to be penetrated is absolutely essential to an intelligent search for gas. It must be known that there is a formation of rocks lying below, capable of forming a reservoir under favorable conditions. All sandstone formations are porous, and all limestone formations are porous in certain areas. The shales, of course, as a rule, are impervions, but these are important, as they form the impenetrable covering for the gas, of which they are, probably, largely the source. Wherever it is known that there is an under-lying deposit of limestone or sandstone, over which there is a considerable thickness of impervious shale, it may be safely assumed that there is a possibility of finding gas in that locality. Careful examinations should be made to determine whether or not there have been structural disturbances of the strata. If the rocks have been greatly tilted, or fissured by upheaval, it will be a waste of means to attempt to get gas in that locality. But if the effect of the disturbance has been merely to wrinkle the strata, if the compression has been just sufficient to produce a series of low folds, or arches, then explorations may be prosecuted in that locality with the greatest of confidence. In locating wells in such territory, care should be taken to determine, as accurately as possible, the summits of the arches or folds. The location of a well, in unexplored territory, where the structural features admit it, should be upon an arch.

In areas where structural disturbances have not occurred, it is only necessary to acquire a thorough knowledge of the strata to be penetrated. It is not at all likely that structural changes assisted in any way in the generation of gas; hence the confinement of gas in the rocks does nor depend upon structural conditions. Where structural changes have occurred in gas reservoirs, the accumulations of stored gas have been affected to some extent, inasmuch as the filling of the synclines with water would force the gas into the arches; but it will probably be developed sooner or later that there are vast accumulations of both gas and oil in areas where structural disturbances have never occurred.

STRUCTURAL FEATURES OF INDIANA.

The surface elevations of Indiana vary from about 375 feet above sea level along the Ohio River in Vanderburg and Posey Counties, to 1,250 feet or more above in Randolph County.

There is, therefore, a difference of about 900 feet in the extreme elevations of the State. The average altitude is about 800 feet above sea level. The surface consists of one broad plain, broken only by the eroded valleys of the streams, and is a part of the eastern portion of the great Mississippi basin. The northern half of the State consists of a broad expanse of generally level lands, interrupted only by the gentle slopes of the water courses. Very few exposures of rocks occur throughout this portion of the State, the surface deposits being almost wholly of glacial origin.

The southern part of the State is, in many of the counties, considerably broken by the erosions of the numerous streams.

The general direction of the drainage line is southwesterly, following, as a rule, the direction of the dip of the strata in the southern part of the State. In the extreme northeast corner of the State the drainage is northeasterly, and in the northwest corner of the State, westerly.

The oldest rock formations are exposed in the southeastern part of the State. The rocks exposed there are those of the Lower Silurian formation, and are equivalent to the Hudson River rocks of New York. These rocks are the surface rocks, or may be seen outcropping in the following counties, viz.: Clark, Dearborn, Decatur, Fayette, Franklin, Jefferson, Ohio, Ripley, Switzerland, Union and Wayne. The greatest thickness of exposed Hudson River rocks, in this State, so far as my knowledge extends, is 536 feet, in Dearborn County. The greatest accumulations of Hudson River rocks yet penetrated by the drill are at Greensburg, Decatur County, where they are 713 feet thick.

From the various exposures of these rocks, or, at least, from the extreme limits of the exposures, there is a dip, more or less rapid, to the north, northwest, west and southwest. The extent of this dip varies considerably, in some places being scarcely distinguishable, while in others it amounts to 50 feet or more to the mile. The more rapid dips are to the north in the northern part of the State, and to the southwest in the southern part of the State.

The rocks that immediately underlie the Hudson River rocks in Indiana are the Utica shales. The drill, within the past year, has revealed the fact that these shales underlie every portion of the State. They vary in thickness from 20 to about 400 feet. Lying immediately below the bluish-gray limestones and shales of the Hudson River rocks, they may usually be recognized by their black or brownish-black color.

Immediately below the Utica shales lie the Trenton limestones. This group, which derives its name from the exposures at Trenton Falls, New York, has a thickness of 451 feet at Lawrenceburg, Indiana, 522 feet at Connersville, 510 feet at Richmond, 620 feet at Indianapolis, 626 feet at Bloomington, and 434 feet at Delphi, Indiana. These rocks, like the Utica shales, underlie every portion of the State.

Just underneath the Trenton rocks is a great sandstone deposit, of unknown thickness, which, for various reasons, I conclude is the Potsdam sandstone.

The Potsdam Sandstone.—This group, like the Trenton and Utica, probably underlies the whole of Indiana. Lying, as it does, several hundred feet beneath the surface, it is impossible to identify it positively without the aid of characteristic fossils, and these, of course, have not been found in the few wells that have penetrated this rock. At Lawrenceburg, Connersville, and some other points in the eastern part of the State, where it has been reached by the drill, it is a fine-grained, hard, pinkish or brownish colored sandstone, without any traces of lime. At Indianapolis it is still a fine-textured, hard and pure sandstone.. At Bloomington, where it was penetrated to the depth of 274 feet, it is somewhat coarse, white, and quite friable, or incompletely cemented at the top, becoming finer and harder lower down, with a considerable proportion of iron. At 270 feet it contains a considerable amount of lime. At Delphi, where the drill penetrated it 10 feet, it is a fine-grained, even-textured sandstone, nearly pure white, and almost pure silica. Throughout the whole of the eastern part of the State it is almost uniform in color, compactness and texture.

The Potsdam sandstone was found at a depth of 293 feet below sea level at Lawrenceburg, 402 feet below at Connersville, 580 feet below at Union City, 799 feet below at Indianapolis, 734 feet below at Delphi, and 1,734 feet below at Bloomington. The dip from Lawrenceburg to Bloomington, a distance of 104 miles westward, is 1,441 feet, or 14 feet to the mile. From Lawrenceburg to Union City, 95 miles due north, the dip is 287 feet, only 3 feet to the mile. From Lawrenceburg to Connersville, 45 miles north, the dip is 109 feet, $2\frac{1}{2}$ feet to the mile. From Connersville to Indianapolis, 57 miles west, the dip is 397 feet, or 7 feet to the mile.

There are, doubtles, numerous contortions, or wave-like folds in these rocks at many points intervening between the places enumerated, but as the drill has penetrated to greater depths than the Trenton rocks at but few places, the arches and troughs have not been revealed. So far, the Potsdam sandstone has not been penetrated at any point north of the Wabash River.

The Potsdam sandstones have never yet yielded gas nor oil in paying quantities, if, indeed, in any quantity at all. The name was derived from the exposures at Potsdam, Lawrence County, New York.

The Trenton Limestones.—These rocks, although they are not exposed at any point in this State, on account of the vast accumulations of natural gas and petroleum found within them, have recently attained an importance scarcely exceeded by any other group of rocks within the borders of the State. They lie immediately above the Potsdam sandstones, and approach nearest the surface at Lawrenceburg, in the extreme southeastern corner of the State, where they are found in well No. 1, at a depth of 349 feet, 158 feet above sea level. At Brookville, 30 miles north of Lawrenceburg, they are 550 feet below the surface, and 174 feet above sea level. At Connersville, 25 miles north of Brookville, they are 705 feet below the surface in well No. 2, and 117 feet above sea level. At Cambridge City, 13 miles north of Connersville, they are 766 feet below the surface, and 174 feet 6 inches above sea level. At Winchester, 25 miles north of Cambridge City, in well No. 3, they are 1,076 feet 6 inches below the surface, and 68 feet 6 inches above sea level. At Ridgeville, 8 miles north of Winchester, they are 981 feet below the surface, and 1 foot above sea level. At Portland, 11 miles north of Ridgeville, they are, in well No. 3, 981 feet 3 inches below the surface, and 59 feet 3 inches below sea level. At Decatur, 27 miles north of Portland, they are 1,030 feet below the surface, and 223 feet below sea level. At Ft. Wayne, 21 miles north of Decatur, they are 1,437 feet below the surface, in well No. 2, and 650 feet below sea level. At Auburn, 28 miles north of Ft. Wayne, they are 1,937 feet below the surface, and 1,069 feet below sea level. At Butler, 11 miles northeast of Auburn, they are 2,057 feet below the surface, and 1,194 feet below sea level.

The following table, No. 1, shows the consecutive strata encountered in boring wells at each of the places above mentioned, with the thickness of each stratum, total depth of well, and the distance above or below sea level at which Trenton limestone was reached. Three wells have been drilled at Lawrenceburg, four at Brookville, four at Connersville, one at Cambridge City, six at Winchester, two at Ridgeville, seventeen at Portland, two at Decatur, five at Ft. Wayne, two at Auburn and one at Butler.*

* At the time this report was written.

TABLE No. I.

	Drift.	Waterlime.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Potsdam.	Trenton Below Sea Level.	Total Depth.
Lawrenceburg	139	...	...	...	185	25	451	40	*158	840
Brookville	...	...	...	...	518	32	120	...	*174	670
Connersville	90	...	...	...	375	240	61	...	*117	766
Cambridge City	96	...	2	...	400	268	133	...	*174	900
Winchester	131	...	69	22	553	240	95	...	*53	1,110
Ridgeville	30	...	200	12	436	303	167	...	*1	1,148
Portland, No. 2	58	...	192		500	240	24	...	63	924
Decatur	39	30	450	20	291	200	10	...	223	1,040
Ft. Wayne, No. 1	77	30	550	20	400	351	70	...	693	1,498
Auburn	280	†120	‡963	...	300	268	27	...	1,069	1,964
Butler	378	†108	‡1,064	...	300	200	89	...	1,194	2,139

* Trenton above sea level.
† Black shale, 120 feet.
‡ Corniferous, Waterlime and Niagara.

Trenton rock rises from Lawrenceburg to Brookville, falls from Brookville to Connersville, rises from Connersville to Cambridge City, and falls gradually from Cambridge City to Ft. Wayne and northward, at the rate of about $5\frac{1}{2}$ feet to the mile. In Steuben County it will probably be found in the neighborhood of 1,400 feet below sea level.

At North Vernon, Jennings County, fifty miles west of Lawrenceburg, Trenton rock is found 980 feet below the surface and 253 feet below sea level. At Greensburg, twenty-five miles north of Vernon, it is 920 feet below the surface and 22 feet above sea level. At Rushville, twenty miles north of Greensburg, it is 860 feet below the surface and $124\frac{41}{100}$ feet above sea level. At New Castle, twenty-five miles north of Rushville, it is 876 feet below the surface, in well No. 1, and 104 feet above sea level. At Muncie, sixteen miles north of New Castle, it is 898 feet below the surface, in well No. 1, and 77 feet above sea level. At Eaton, eleven miles north of Muncie, it is 890 feet below the surface, and 20 feet below sea level. At Hartford City, seven miles north of Eaton, it is 935 feet below the surface, in well No. 2, and 40 feet below sea level. At Montpelier, nine miles north of Hartford City, it is 962 feet below the surface, and 110 feet below sea level. At Bluffton, thirteen miles northeast of Montpelier, it is 1,075 feet below the surface, in well No. 2, and 223 feet below sea level. At Huntington, twenty miles northeast of Bluffton, it is 995 feet below the surface, in well No. 1, and 255 feet below sea level. At Columbia City, twenty miles north of Huntington, it is 1,367 feet below the surface, and 545 feet below sea level. At Albion, twenty miles north of Columbia City, it is 1,980 feet below the surface, and 973 feet below sea level.

The following table, No 2, shows the thickness of the strata encountered at the various points above mentioned, total depth of well and distance of Trenton above or below sea level.

TABLE No. II.

	Drift.	Devonian Shale.	Carniferous Limestone.	Lower Helderburg or Waterlime.	Niagara Limestone.	Clinton Limestone.	Hudson River Limestone and Shale.	Utica Shales.	Trenton Limestone.	Trenton Below Sea Level.	Total Depth.
North Vernon	11	. .	58	. . .	222	29	440	220	470	253	1,450
Greensburg, No. 1. . . .	7	. . .	. . .	. .	90	. . .	713	110	63	*22	983
Rushville, No. 1.	60	. . .	40	.	180	20	300	260	124	*124	984
New Castle, No. 1. ...	333	. . .	. .	. . .	. . .	. . .	200	343	421	*104	1,297
Muncie, No 1.	. . .	. . .	. . .	. . .	265	. . .	300	311	22	*77	898
Eaton, No. 1.	. .	. .	. . .	. . .	190	10	400	290	32	12	922
Hartford City, No. 2 ..	82	. . .	. . .	. .	180	. . .	533	140	32	40	967
Montpelier, No. 1. ...	17	. .	. . .	. . .	233	. . .	450	262	19	110	981
Bluffton, No. 2	51	.	. . .	30	479	. .	340	175	31	238	1,106
Huntington, No. 1 ..	2	. . .	. . .	38	370	. . .	275	320	39	255	1,034
Columbia City	224	. . .	. .	46	480	. . .	400	218	40	546	1,409
Albion	375	65	65	†35	815	.	285	250	24	973	1,914

* Above sea level.

† Oriskany, probably 5 ft.

The drill has revealed that the Trenton limestones rise 275 feet from North Vernon to Greensburg, a distance of 25 miles, or 11 feet to the mile; from Greensburg to Rushville, a distance of 20 miles, they rise 102 feet, but a little more than 5 feet to the mile; from Rushville to New Castle, 24 miles, they fall 20 feet, less than 1 foot to the mile; from New Castle to Muncie, 18 miles distant, they fall 27 feet, $1\frac{1}{2}$ feet to the mile; from Muncie to Eaton, distant 11 miles, they fall 91 feet, more than 8 feet to the mile; from Eaton to Montpelier, distant 16 miles, they fall 98 feet, about 6 feet to the mile; from Montpelier to Huntington, distant about 22 miles, they fall 145 feet, about 7 feet to the mile; from Huntington to Columbia City, distant 20 miles, they fall 291 feet, nearly 15 feet to the mile, and from Columbia to Albion, distant about 22 miles, they fall 427 feet, about 20 feet to the mile.

At Jeffersonville, on the Ohio River, the Trenton rocks lie 856 feet below the surface, and 401 feet below sea level; at Seymour, 49 miles north, they lie 1,100 feet below the surface, and 472 feet below sea level; at Columbus, 18 miles north of Seymour, they are 955 feet below the surface, and 325 feet below sea level; at Shelbyville, 24 miles north of Columbus, they are 837 feet below the surface, in well No. 1, and 79 feet below sea level; at Greenfield, 18 miles north of Shelbyville, they are 985 feet below the surface, in well No. 1, and 54 feet below sea level; at Anderson, 22 miles north of Greenfield, they are 814 feet below the surface, in well No. 2, and 66 feet above sea level; at Marion, 31 miles north of Anderson, they are 878 feet below the surface, in well No. 3, and 67 feet below sea level; at La Fontaine, 10 miles north of Marion, they are 900 feet below the surface, and 6 feet below sea level; at Wabash, 10 miles north of La Fontaine, they are 878 feet below the surface, and 198 feet below sea level; at North Manchester, 15 miles north of Wabash, they are 1,030 feet below the surface, and 255 feet below sea level; at Warsaw, 19 miles north of North Manchester, they are 1,387 feet below the surface, and 570 feet below sea level; at Goshen, 24 miles north of Warsaw, they are 1,815 feet below the surface, and 1,076 feet below sea level.

The following table, No. 3, shows the thickness of the strata encountered in wells at the various points mentioned above, together with the total depth of the wells, and distance of Trenton rock above or below sea level:

TABLE No. III.

STATIONS.	Drift.	Devonian Shale.	Corniferous.	Lower Helderburg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Jeffersonville	45	. .	40	. . .	105	20	500	146	. .	401	856
Seymour	75	130	25	. . .	190	. .	500	165	94	472	1,194
Columbus	26	74	21	. . .	259	. . .	440	135	155	325	1,110
Shelbyville, No. 1	48	. . .	20	. . .	202	.	450	117	86	79	923
Greenfield, No. 1	205	. . .	. .	. . .	170	. .	400	210	14	54	999
Anderson, No. 2	114	. . .	. . .	. .	186	20	440	54	24	*66	838
Marion, No. 5	185	. . .	. . .	.	145	. . .	350	220	36	49	906
La Fontaine	300	. . .	. . .		225	. .	175	200	23	6	923
Wabash, No. 1	25	. . .	. . .	40	425	30	200	158	54	138	932
North Manchester	274	. . .	. . .	. . .	300	. . .	250	306	50	355	1,180
Warsaw, No. 1	224	. . .	. .	60	592	. . .	200	287	. . .	570	1,464
Goshen	165	308?	60	32	728	. . .	307	215	. . .	1,076	. . .

* Trenton above sea level.

The stations mentioned in the foregoing table are all very near to a due north and south line running entirely through the State. Anderson, almost in the center, is on the summit of the Trenton rocks. At this point they are 66 feet above sea level. Southward, from Anderson to Greenfield, the dip is nearly 6 feet to the mile; from Greenfield to Shelbyville it is 1 foot to the mile; from Shelbyville to Columbus it is 10 feet to the mile; from Columbus to Seymour it is 8 feet to the mile; from Seymour to Jeffersonville it is northward $1\frac{1}{2}$ feet to the mile. Northward, from Anderson to Marion, the dip is 4 feet to the mile. From Marion to La Fontaine the Trenton rocks rise at the rate of 4 feet to the mile, but they fall from La Fontaine to Wabash at the rate of 13 feet to the mile. From Wabash to North Manchester the dip is 15 feet to the mile; from North Manchester to Warsaw it is 12 feet to the mile, and from Warsaw to Goshen, 25 feet to the mile.

At the Gas Works well, Indianapolis, Trenton rock is 179 feet below sea level; at Broad Ripple, nine miles north, it is 109 feet below sea level; at Noblesville, eleven miles north of Broad Ripple, it is 76 feet below sea level in the Banner well; at Tipton, seventeen miles north of Noblesville, it is 129 feet below sea level in well No. 1; at Kokomo, fifteen miles north of Tipton, it is 97 feet below sea level in well No. 4; at Peru, twenty-one miles north of Kokomo, it is 229 feet below sea level in well No. 2.

The following table, No. 4, gives a record of the strata passed through in boring wells at the stations mentioned along the line of the Lake Erie & Western Railroad from Indianapolis to Peru:

TABLE No. IV.

STATIONS.	Drift.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.	Remarks.
Indianapolis	118	. .	68	20	200	20	300	74	620	179	1,520	Dry.
Broad Ripple	55	. .	28	20	257	20	400	84	24	109	888	Gas.
Noblesville, No. 5	73	. .	. .	. .	239	30	350	126	9	76	853	Gas.
Tipton, No. 1	139	. .	. .	30	260	36	400	132	33	129	1,030	A little gas & oil.
Kokomo, No. 4	61	. .	. .	59	270	30	265	251	22	97	958	Gas.
Peru, No. 2	10	. .	. .	50	360	15	249	200	27	229	956	Dry.
Rochester	245	. .	. .	. .	525	. .	200	191	24	351	1,185	

From Indianapolis to Broad Ripple the Trenton rocks rise at the rate of 8 feet to the mile; from Broad Ripple to Noblesville they rise at the rate of 3 feet to the mile; from Noblesville to Tipton they fall at the rate of 3 feet to the mile; from Tipton to Kokomo, they rise at the rate of 2 feet to the mile; from Kokomo to Peru they fall at the rate of 6 feet to the mile

At Martinsville, Morgan County, the Trenton limestones are 780 feet below sea level; at Bridgeport, twenty-one miles north, they are 247 feet below sea level; at Lebanon, twenty-two miles north, and six miles west of Bridgeport, they are 302 feet below sea level; at Frankfort, eighteen miles north of Lebanon, they are 227 feet below sea level; at Delphi, twenty miles north of Frankfort, they are 334 feet below sea level in well No. 1, and 350 feet below sea level in well No. 2.

The following table, No. 5, shows the thickness of the different groups of rock encountered in boring wells at the places above mentioned, together with the depth to Trenton, total depth of well, etc.:

TABLE No. V.

STATIONS.	Drift.	Sub-Carb.	Devonian Shale.	Corniferous.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.	Remarks.
Martinsville.	85	323	120	62	216	20	420	131	51	780	1,448	No gas.
Bridgeport	140	. . .	134	20	220	24	455	55	70	247	1,108	No gas.
Lebanon.	378	. . .	. . .	. .	. .	. .	. . .	. .	.	302	1,800	No gas.
Frankfort	278	. . .	. . .	60	300	30	250	150	260	227	1,328	No gas.
Delphi, No. 1 . . .	. . .	. . .	. . .	. .	587	. .	220	93	12	334	912	No gas.

From Martinsville to Bridgeport the Trenton limestones rise 533 feet, or nearly 24½ feet to the mile; from Bridgeport to Lebanon they fall 55 feet, about 2½ feet to the mile; from Lebanon to Frankfort they rise 75 feet, or 4 feet to the mile; from Frankfort to well No. 1, Delphi, they fall 107 feet, or 5½ feet to the mile.

In well No. 1, at Delphi, the Trenton limestones were reached at a depth of 334 feet below sea level, while in well No. 2, bored near by, they were found 16 feet lower down, or 350 feet below sea level. This fact clearly proves that the marked disturbances in the strata so clearly disclosed in the surface exposures at that place are just what the common observer will conclude that they are, simply distortions produced by physical or mechanical forces.

The paper entitled "The Wabash Arch," which appeared in the Fifteenth Report of the State Geologist, was written before the first well was drilled in the Indiana gas field, and the conclusions therein presented were the result of superficial examinations only, but the later facts revealed by the drill in the numerous gas wells of the State, when carefully studied, furnish still stronger and more direct evidence of the correctness of those first conclusions. The views set forth in that first article were undoubtedly correct in the main.

At Bloomington, Monroe County, the Trenton limestones lie 1,108 feet below sea level; at Crawfordsville, seventy-three miles north, they are 664 feet below sea level; at the Lafayette well No. 1, near Porter Station, thirty-two miles north of Crawfordsville, they are 548 feet below sea level; at Monticello, twenty-two miles north and a little east of the Lafayette well, they are 338 feet below sea level; at Francisville, nineteen miles north of Monticello, they are 200 feet below sea level; at Valparaiso, thirty-six miles north, and a little west of Francisville, they are 602 feet below sea level.

The following table, No. 6, shows the thickness of the strata encountered in wells at each of the points mentioned above, together with the depth of Trenton rock below sea level, and the total depth of well.

TABLE No. VI.

STATIONS.	Drift.	Sub.-Carb.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Bloomington	6	749	155	15	.	240	. .	485	180	626	1,108	2,730
Crawfordsville	140	410	80	55	. . .	380	. .	250	115	69	664	1,49[illegible]
Lafayette, No. 1		100	120	60	. .	100	. .	288	110	72	548	1,206
Monticello	205	.	. . .	. .	40	465	. .	120	170	63	338	1,073
Francisville	8	. . .	. . .	. .	60	542	. .	235	100	10	200	895
Valparaiso	125	. . .	65	70	80	505	. .	260	195	144	602	1,444

From Bloomington to Crawfordsville the Trenton limestones rise at the rate of about 6½ feet to the mile; from Crawfordsville to Lafayette they rise at the rate of about 4 feet to the mile; from Lafayette to Monticello they rise at about the rate of 9½ feet to the mile; from Monticello to Francisville they rise at the rate of a little more than 7 feet to the mile, but from Francisville to Valparaiso they fall at the rate of about 14 feet to the mile. At Francisville the Trenton limestones are 402 feet higher than they are at Valparaiso, a little more than thirty miles north, and 348 feet higher than they are at Lafayette, about the same distance south, and 464 feet higher than they are at Crawfordsville, still farther south. The total elevation of the Wabash Arch in this portion of the State approximates 500 feet, even if it does not exceed that height. Whatever the causes that produced this elevation, and whatever differences of opinion may be entertained concerning its origin, the facts of its existence are absolute. But when the distorted and tilted condition of the exposed rocks throughout this region are considered, together with the continued, and, in many places, the abrupt dip of the strata southward and northward from it, the conclusion is forced that it was produced by the physical forces of nature, at a period infinitely remote.

At Rockville, Parke County, Trenton rock is 1,412 feet below sea level; at Oxford, Benton County, fifty miles north, it is 570 feet below sea level; at Fowler, seven miles north of Oxford, it is 181 feet below sea level; at Kentland, twelve miles northwest of Fowler, it is 370 feet below sea level; at Rensselaer, seventeen miles northeast of Kentland, it is 162 feet below sea level. The dip from Fowler to Kentland, northwest, is a little more than 7 feet to the mile; from Fowler to Oxford, south, it is 58 feet to the mile, and from Oxford to Rockville it is about 17 feet to the mile; from Rensselaer to Kentland, south, it is 6½ feet to the mile.

The following table, No. 7, gives the thickness of the strata encountered in wells at the above mentioned stations, together with depth to Trenton, total depth of wells, etc.:

TABLE No. VII.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.	Remarks.
Rockville	96	259	689	102	62	. .	370	324	108	10	1,412	2,110	Dry.
Oxford	385	. .	. .	100	45	. .	385	185	188	. .	570		
Fowler	280	. .	. .	92	45	. .	238	185	155	. .	181	995	
Kentland	100	. .	. .	100	45	. .	305	300	210	60	370	1,120	
Rensselaer	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	158	896	

We have no accurate records of any wells due north of Kentland, Ind., showing the thickness of the strata nor the dip of the rocks.

The seven tables given above give a very correct idea of the variations in altitude of the Trenton limestone in a north and south direction through the State. Sections of wells will be given further on, which show more marked irregularities of structure than the foregoing. Great care has been taken to procure the most reliable data concerning the many wells bored for natural gas throughout the State, and the sections given herewith may be regarded as the most reliable that it has been possible to procure.

To more thoroughly show the position of Trenton rock, as regards sea level, the following tables are presented, which show its dip, or variations in elevation on lines running easterly and westerly through the State. These in a number of instances include wells not given in the seven preceding tables.

At Lawrenceburg, Dearborn County, the Trenton limestones are 158 feet above sea level; at North Vernon, fifty miles west, they are 253 feet below sea level; at Seymour, fifteen miles west of North Vernon, they are 472 feet below sea level.

The following table, No. 8, shows the thickness of the strata encountered in the wells at each of the places mentioned, depth of Trenton above or below sea level, etc.:

TABLE No. VIII.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Lawrenceburgh	139	..	..	..	.	..	...	..	185	25	451	*158	840
North Vernon	11	..	..	..	58	..	222	29	440	220	470	253	1,450
Seymour	75	..	..	130	25	..	190	..	500	165	94	472	1,194

*Trenton above sea level.

From Lawrenceburg to North Vernon the dip of Trenton rock is a little more than 8 feet to the mile, and from North Vernon to Seymour it is a little more than 14½ feet to the mile.

At Brookville, Franklin County, about thirty miles north of Lawrenceburg, the Trenton limestones are 174 feet above sea level; at Greensburg, twenty-six miles west and six miles south of Brookville they are 24 feet above sea level; at Columbus, twenty-two miles west, and about eight miles south of Greensburg they are 325 feet below sea level, and at Bloomington, thirty-three miles west of Columbus, they are 1,108 feet below sea level. From Brookville to Greensburg the dip is at the rate of 6 feet to the mile, from Greensburg to Columbus it is at the rate of 16 feet to the mile, and from Columbus to Bloomington it is at the rate of nearly 24 feet to the mile.

The following table, No. 9, gives the thickness of the strata encountered in drilling wells at Brookville, Greensburg, Columbus and Bloomington, with the distance of Trenton rock above or below sea level, total depth of well, etc.:

TABLE No. IX.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Brookville	..	..	...	...	..	...	..	..	518	32	120	*174	670
Greensburg	7	..	...	...	.	...	90	..	713	110	63	*22	984
Columbus	26	..	..	74	21	...	259	..	440	135	155	325	1,110
Bloomington	6	..	749	155	15	...	240	..	485	180	626	1,108	2,730

*Trenton above sea level.

Connersville, Fayette County, is twenty-five miles north of Brookville. At Connersville the Trenton limestones are 117 feet above sea level; at

Rushville, eighteen miles west of Connersville, they are 124 feet above sea level; at the Muth well, Morristown, fifteen miles west of Rushville, they are 44 below sea level; at Shelbyville, fifteen miles southwest of Morristown, they are 79 feet below sea level: at Martinsville, thirty-six miles west of Shelbyville, they are 780 feet below sea level.

From Connersville to Rushville the Trenton rocks rise at the rate of about one-half foot to the mile; from Rushville to Morristown the dip is at the rate of about 11 feet to the mile; from Morristown to Shelbyville the dip is at the rate of 2½ feet to the mile; from Shelbyville to Martinsville the dip is at the rate of about 19 feet to the mile.

The following table, No. 10, shows the thickness of strata passed through in boring wells at the several places mentioned, the elevation of Trenton rock as compared with sea level, total depth of wells, etc.:

TABLE No. X.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton below sea level.	Total depth.
Connersville, No. 2 . .	90	. .	. .	. .	. .	. .	. .	. . .	375	240	61	*117	766
Rushville	60	. .	. .	. .	40	. .	180	20	300	260	124	*124	984
Morristown	140	. .	. .	. .	. .	. .	130	. . .	450	178	23	44	921
Shelbyville	48	. .		. .	20	. .	202		450	117	86	79	923
Martinsville	85	. .	323	120	62	. .	216	202	420	131	51	780	1,448

Richmond, Ind., is about twenty miles north of Connersville, and fifteen miles east. At Richmond the Trenton limestone is 79 feet above sea level: at Cambridge City, fifteen miles west, it is 174 feet above sea level; at Knightstown, nineteen miles west of Cambridge City, it is 113 feet above sea level; at Greenfield, thirteen miles west of Knightstown, it is 54 feet below sea level; at Indianapolis, twenty miles west of Greenfield, it is 179 feet below sea level; at Bridgeport, nine miles west of Indianapolis, it is 247 feet below sea level, and at Rockville, fifty miles west of Bridgeport, it is 1,412 feet below sea level.

The dip of rocks from Cambridge City eastward to Richmond is at the rate of about 6 feet to the mile, and from Cambridge City to Knightstown westward, it is at the rate of but little more than 3 feet to the mile. From Knightstown to Greenfield the dip is at the rate of about 13 feet to the mile, but from Greenfield to Indianapolis it is little more than 6 feet to the mile. From Indianapolis to Bridgeport the rocks dip at the rate of 7½ feet to the mile, and from Bridgeport to Rockville at the rate of 23 feet to the mile.

The following table, No. 11, shows the thickness of the various groups of rocks encountered in boring wells at the points named, together with the altitude of Trenton limestone with respect to sea level, total depth of well, etc.:

TABLE No. XI.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Corniferous.	Lower Helderberg.	Niagara.	Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Richmond	...	..	..	..	..	..	...	..	500	380	5'0	*79	1,400
Cambridge City	96	..	..	..	..	..	2	..	400	268	133	*174	900
Knightstown	64	..	..	..	..	..	260	..	300	199	213	*113	1,036
Greenfield	205	..	.	..	.		170		400	210	14	54	999
Indianapolis	118	..	.	..	68	20	200	20	300	74	620	179	1,520
Bridgeport	140		..	124	20	..	244	..	455	55	70	247	1,108
Rockville	96	259	689	102	62		370	..	324	108	10	1,412	2,110

* Trenton above sea level.

At Winchester the top of Trenton limestone is 43 feet above sea level in well No. 1. From Winchester to Muncie it rises at the rate of nearly 3 feet to the mile, and in well No. 1, at the latter place, it is 97 feet above sea level. From Muncie to Anderson there is a dip of 2 feet to the mile; from Anderson to Noblesville the dip is greater, being at the rate of 7½ feet to the mile. From Noblesville to Lebanon the dip increases to 9 feet to the mile, and from Lebanon to Crawfordsville it is still more rapid, being at the rate of 18 feet to the mile.

The following table, No. 12, gives the records of wells at the points mentioned above, showing thickness of strata, etc.:

TABLE No. XII.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Upper Helderberg or Corniferous.	Lower Helderberg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Winchester, No. 1	147	..	...	...	...	...	71	582	250	90	*43	1,140
Muncie, No. 1	...	..	...	...	...	...	265	400	211	22	*97	898
Anderson	114	..	...	...	...	...	206	440	54	24	*66	838
Noblesville, Banner Well	73	..	...	...	..	..	236	300	76	9	76	853
Lebanon	...	..			...	...	..	. .		..	302	1,800
Crawfordsville	140	..	410	80	55	...	380	250	115	69	664	1,499

* Trenton abo sea level.

At Portland, Jay County, the top of Trenton limestone is 90 feet below sea level in well No. 2; at Hartford City, twenty-two miles west, it is 40 feet below sea level, the eastward dip between the two points being at the rate of a little more thon 2 feet to the mile. From Hartford City to Fairmount, twenty miles west, the westward dip is only 1 foot in twenty miles, the top of the limestone being 41 feet below sea level in well No. 1, at the latter point. From Fairmount to Kokomo the dip is at the rate of a little more than 2 feet to the mile; from Kokomo to Lafayette it is at the rate of 10 feet to the mile, and from Lafayette to Oxford, Benton County, it is at the rate of only 1 foot to the mile.

The following table, No. 13, shows the thickness of the various groups of rocks encountered in drilling wells at the points mentioned above, together with depth of Trenton limestone below sea level, etc.:

TABLE No. XIII.

STATIONS.	Drift.	Coal Measures.	Sub-Carboniferous.	Devonian Shale.	Upper Helderberg.	Lower Helderberg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Portland, No. 2. . . .	58	. .	. .	. . .	. .	.	192	500	240	14	90	1,004
Hartford City	82	. .	. . .	. . .	. . .	. . .	180	533	140	28	40	963
Fairmount, No. 1. . .	35	. .	. . .	. .	. .	. . .	309	350	240	31	41	965
Kokomo, No 4	61	. .	. . .	. . .	. . .	30	329	265	251	22	97	958
Lafayette, Porter's. .		. .	280	. . .		. . .	350	300	198	20	548	1,148
Oxford	385	. .	. . . .	100	50	30	265	255	188	20	570	1,293

At Decatur, Adams County, the top of Trenton limestone is 223 feet below sea level; at Huntington, thirty miles west, it is 247 feet below sea level; at Wabash, nineteen miles west of Huntington, it is 197 feet below; at Logansport, twenty-nine miles west of Wabash, it is 344 feet below; at Monticello, a little more than twenty miles west of Logansport, it is 338 feet below, and at Kentland, about twenty-five miles west of Monticello, it is 379 feet below. The westward dip of the strata from Decatur to Huntington is less than one foot to the mile; from Huntington to Wabash it rises at the rate of about $2\frac{1}{2}$ feet to the mile; from Wabash to Logansport the dip is at the rate of 5 feet to the mile; from Logansport to Monticello it rises at the rate of $\frac{1}{4}$ foot to the mile, and from Monticello to Kentland falls or dips at the rate of $1\frac{1}{2}$ feet to the mile.

Table No. 14 shows the thickness of strata drilled through in wells at the above named places, the depth of Trenton rock below sea level, etc.:

TABLE No. XIV.

TATIONS.	Drift.	Coal Measures.	Sub-Corbon-iferous.	Devonian Shale.	Upper Helderberg.	Lower Helderberg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Decatur	39	...	...	...	...	40	440	300	211	10	223	1,040
Huntington	...	...		...	...	...	441	266	315	..	247	1,022
Wabash, No. 2	28	...	...	...	...	40	485	160	165	54	198	932
Logansport, No. 1	...	...	...	...	...	..	...	...	...	..	344	...
Monticello	205	.	...	...	...	...	515	170	120	63	338	1,073
Kentland,	100	..	...	100	45	..	305	300	210	60	379	1,120

Ft. Wayne is about fifteen miles north of Decatur, and about eight miles west. At Ft. Wayne, in well No. 2, Trenton rock is about 650 feet below sea level; at Columbia City, twenty miles northwest, it is 545 feet below sea level; at Rochester, about thirty-eight miles west, and a little south of Columbia City, it is 351 feet below sea level; at Kewana, eleven miles west of Rochester, it is 274 feet below sea level; at Francisville, twenty miles west of Kewana, it is 200 feet below sea level; at Renssalaer, eleven miles west of Francisville, it is 158 feet below sea level. It will be noticed that there is an eastward dip of the rocks all the way across the State from Renssalaer to Ft. Wayne, the average dip is about 5 feet to the mile.

The following table, No. 15, shows the thickness of the various strata encountered in drilling wells for gas at the points above mentioned, depth to Trenton rock, altitude of Trenton rock as compared with sea level, etc.:

TABLE No. XV.

STATIONS.	Drift.	Coal Measures.	Sub-Carbonif-erous.	Devonian Shale.	Upper Helder-berg.	Lower Helder-berg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Fort Wayne, No. 2	110	..	...	...	...	34	571	410	312	21	650	1,458
Columbia City	224	..	..	...	...	...	526	400	217	39	545	1,407
Rochester	245	..	.	...	40	40	460	260	101	24	351	1,185
Kewana	170	..	...	...	.	..	500	205	175	29	274	1,089
Francisville	8	..	.	...	.	30	512	235	100	10	200	895
Rensselaer	30	..	...	..	...	35	500	225	100	3 0	158	1,275

At Auburn, twenty-two miles north of Ft. Wayne, Trenton rock is 1,069 feet below sea level; at Albion, twenty miles west of Auburn, it is 963 feet below sea level, and at Warsaw, twenty-five miles southwest of Albion, it is 570 feet below sea level. From Warsaw to Albion it dips at the rate of about 8 feet to the mile, and from Albion to Auburn it dips at the rate of about 10 feet to the mile. Throughout this section of the country the dip is either east, northeast or north.

The following table, No. 16, shows the thickness of the strata encountered in drilling wells at the above mentioned places, together with the depth of the Trenton rock, distance of Trenton rock below sea level, etc.:

TABLE No. XVI.

STATIONS.	Drift.	Coal Measures.	Sub-Corbon-iferous.	Devonian Shale.	Upper Helderberg.	Lower Helderberg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Auburn.	280	. .	. . .	120	80	40	823	300	268	27	1,069	1,964
Albion	375	. .	. . .	65	65	35	815	285	250	24	973	1,914
Warsaw.	248	. .	. . .	. . .	. . .	60	652	200	287	. .	570	1,464

Goshen, Ind., is twenty-four miles north of Warsaw. At Goshen the top of Trenton rock is 1,076 feet below sea level, which is 506 feet below the top of the same rock at Warsaw; at South Bend, twenty-five miles west of Goshen, the top of Trenton limestone is 855 feet below sea level; at Valparaiso, forty-five miles west by southwest of South Bend, the top of the same rock is 602 feet below sea level. The dip from Valparaiso to South Bend is about 6 feet to the mile, and from South Bend to Goshen, it is about 9 feet to the mile.

The following table, No. 17, shows the thickness of the strata encountered in drilling wells at the above mentioned places, together with the depth to the top of the Trenton limestone, the distance of Trenton below sea level, etc.:

TABLE No. XVII.

STATIONS.	Drift.	Sub-Carbon-iferous.	Devonian Shale.	Upper Helderberg.	Lower Helderberg.	Niagara and Clinton.	Hudson River.	Utica.	Trenton.	Trenton Below Sea Level.	Total Depth.
Goshen	165	. . .	360	60	32	728	307	215	. . .	1,076	. .
South Bend	160	. . .	220?	60	40	700	200	200	427	855	2,077
Valparaiso	125	. . .	65?	70	80	505	260	195	144	602	1,444

It is easy to discern, after a mere cursory examination of the facts disclosed in the foregoing tables, that there is a general northeasterly dip of the strata in the northern part of the State, and a general southwesterly dip of the strata in the southern part of the State The wide extent of territory included in the Indiana gas area is at the summit of a vast ridge running northwest and southeast, and which slopes off rapidly towards the northeast and the southwest. This ridge extends entirely across the State. The largest accumulations of gas are found along the summit of the ridge, rather than upon the sides. The ridge itself slopes very gradually towards the northwest. A straight line from Cambridge City, where the top of the Trenton limestone reaches its extreme limit of height, 174 feet above sea level, to Renssalaer, Jasper County, also on the summit of the ridge, will pass almost directly through New Castle, Anderson, Tipton, Delphi and Monticello. The following are the elevations of Trenton rock at points named:

Cambridge City	174 ft. above sea level.
New Castle, No. 2	120 ft. above sea level.
Anderson	66 ft. above sea level.
Tipton	127 ft. below sea level.
Delphi, No. 2	350 ft. below sea level.
Monticello.	338 ft. below sea level.
Renssalaer.	158 ft. below sea level.

The extreme elevations of the ridge, however, do not follow an exact line, but swerve to the north somewhat in the vicinity of the Wabash River. Roughly following the summit of the ridge, as far as facts have been disclosed, the following points would be touched: Renssalaer, Francisville, Royal Center, Peru, and from there to Anderson and the other points occurring on the line given above.

The ridge itself, as before stated, slopes off gradually to the northwest. At Cambridge City its summit is 174 feet above sea level; at Renssalaer it is 158 feet below sea level, a fall of 332 feet in a little more than 150 miles, or a little more than 2 feet to the mile. In the vicinity of the Wabash River, however, there is a slight sag or depression of the summit of the ridge, the top of the Trenton limestones being about 75 feet lower in that vicinity than they are at Renssalaer. In speaking of this vast ridge or anticline it is understood, of course, that reference is made wholly to the elevations of strata and not to the surface nor superficial deposits that are not always conformable.

In every direction from the vast plateau-like elevation that contains the Trenton gas, except to the southeast, there is a more or less rapid dip of the strata. Southeast from the gas area the Trenten limestones rise gradually until finally they appear at the surface in northern Kentucky.

In the search for natural gas wells have been drilled in greater or less numbers in nearly every county in the State, and, so far as it has been possible to do so, complete records of these have been obtained. Following will be found a list showing the records of most of the wells drilled prior to October 1, 1888. In many of the wells referred to below little or no gas was found, but since these wells were drilled others have followed in the same locality with productive results.

The sections given will be found convenient for reference and comparison, and for greater convenience the towns enumerated have been arranged alphabetically.

SECTIONS OF NATURAL GAS WELLS IN INDIANA.

ALBION.

Section of Well No. 1.

Drift	375 feet.
Devonian shale	65 "
Devonian limestone	65 "
Sandstone	5 "
Hydraulic limestone	30 "
Niagara and (Clinton?) limestone and shale	815 "
Hudson River limestone and shale	285 "
Utica shale	250 "
Trenton limestone	24 "
Total depth	1,914 feet.
Trenton below sea level	973 "

Yielded small flow of gas.

ALEXANDRIA.

Section of Well No. 1.

Drift	20 feet.
Niagara limestone	261 "
Hudson River and Utica	611 "
Trenton limestone	5 "
Total depth	897 feet.
Trenton below sea level	40 "

Yielded strong flow of gas.

AMBOY.

Section of Well No. 1.

Drift	35 feet.
Niagara limestone and shale	350 "
Hudson River and Utica	522 "
Trenton limestone	33 "
Total depth	940 feet.

Yielded strong flow of gas.

ANDERSON.

Section of McCullough Well, No. 2.

Drift	114 feet.
Niagara limestone and shale	186 "
Clinton (?)	20 "
Hudson River and Utica	494 "
Trenton limestone	24 "
Total depth	838 feet.
Trenton above sea level	66 "

Yielded very strong flow of gas.

ANDREWS.

Section of Well No. 1.

Drift	70 feet.
Niagara limestone	300 "
Hudson River and Utica	562 "
Trenton limestone	36 "
Total depth	968 feet.

Yielded no gas.

AUBURN.

Section of Well No. 1.

Drift	280 feet.
Black shale	120 "
Corniferous, Water-lime and Niagara	963 "
Hudson River limestone and shale	306 "
Utica shale	268 "
Trenton limestone	27 "
Total depth	1,964 feet.

The pressure of this gas well was 350 pounds in two hours. In five minutes it went to 125 pounds, in 13 minutes to 200 pounds, in 48 minutes to 300 pounds, and in two hours to 350 pounds. The volume of gas is very strong.

BLUFFTON.

Section of Well No. 1.

Drift	12 feet.
Niagara limestone and shale	413 "
Hudson River limestone and shale	340 "
Utica shale	285 "
Trenton limestone	150 "
Total depth	1,200 feet.
Trenton below sea level	213 "

Yielded no gas.

BLUFFTON.

Section of Well No. 2.

Drift	51 feet.
Water lime	30 "
Niagara limestone	479 "
Hudson River limestone and shale	340 "
Utica shale	175 "
Trenton limestone	31 "
Total depth	1,106 feet
Trenton below sea level	238 "

Yielded no gas.

Well No. 2 is located about one-half mile northwest of well No. 1.

BRIDGEPORT.

Section of Well No. 1.

Drift	140 feet.
Devonian shale	124 "
Corniferous limestone	40 "
Niagara limestone	200 "
Hudson River limestone and shale	475 "
Utica shale	55 "
Trenton limestone	74 "
Total depth	1,108 feet.
Trenton below sea level	247 "

Did not yield gas.

BROAD RIPPLE.

Section of Well No. 1.

Drift	55 feet.
Corniferous limestone	48 "
Niagara limestone	257 "
Hudson River and Utica	504 "
Trenton limestone	24 "
Total depth	888 "
Trenton below sea-level	109 "

Yields a small quantity of gas, also a small quantity of oil.

BROOKVILLE.

SECTION OF WELL No. 1.

Hudson River and Utica	550 feet.
Trenton limestone	120 "
Total depth	670 "
Trenton above sea-level	174 '

Produces a small quantity of gas

BROWNSTOWN.

SECTION OF WELL No. 1.

Drift	43 feet.
Knobstone shale	275 "
Devonian shale	147 "
Corniferous and Niagara limestone	225 "
Hudson River and Utica	658 "
Trenton limestone	100 "
Total depth	1,448 feet.

Yielded no gas, but at a depth of 1,371 feet a slight flow of oil was obtained. The bore was continued to a greater depth after this section was obtained.

BRYAN, OHIO.

SECTION OF WELL No. 1.

Drift	176 feet.
Devonian shale	74 "
Corniferous, lower Helderberg and Niagara limestone	1,060 "
Hudson River and Utica	635 "
Trenton limestone	38 "
Total depth	1,983 feet.
Trenton below sea-level	1,180 "

Rock pressure accumulated in ten minutes 185 pounds per square inch.

In well No. 2, at the same place, oil and gas were both found at a depth of 2,035 feet, and salt water at 2,037 feet. In this well Trenton rock was reached at a depth of 1,990 feet, 1,270 feet below sea-level.

BUNKER HILL.

SECTION OF WELL No. 1.

Drift	58 feet.
Corniferous and Niagara limestone	503 "
Hudson River and Utica	431 "
Trenton limestone	12 "
Total depth	1,004 feet.
Trenton below sea level	155 '

BUTLER.

Section of Well No. 1.

Drift	378 feet.
Hamilton shale	108 "
Corniferous Water-lime and Niagara	1 064 "
Hudson River and Utica	500 "
Trenton limestone	89 "
Total depth	2,139 feet.
Trenton below sea level	1,187 "

Yielded small flow of gas, which was found at a depth of 27 feet in Trenton rock.

CAMBRIDGE CITY.

Section of Well No. 1.

Drift	96 feet.
Niagara limestone	2 "
Hudson River and Utica	668 "
Trenton limestone	134 "
Total depth	900 feet.
Trenton above sea level	174 ft. 6 in.

Did not yield gas.

CICERO.

Section of Well No. 1.

Drift	161 feet.
Niagara limestone and shale	300 "
Hudson River and Utica	490 "
Trenton limestone	32 "
Total depth	983 feet.

A medium flow of gas was found at a depth of 966 feet, and a considerable flow of oil at $974\frac{5}{10}$ feet, the yield of which is 5 to 20 barrels per day.

COLUMBIA CITY.

Section of Well No. 1.

Drift	224 feet.
Niagara limestone and shale	526 "
Hudson River limestone and shale	400 "
Utica shale	218 "
Trenton limestone	39 "
Total depth	1,407 feet.
Trenton below sea level	545 "

Yielded a trace of gas.

COLUMBUS.

SECTION OF WELL NO. 1.

Drift	26 feet.
Devonian shale	87 "
Corniferous limestone	32 "
Niagara limestone	235 "
Hudson River limestone and shale	440 "
Utica shale	135 "
Trenton limestone	155 "
Total depth	1,110 feet.
Trenton below sea level	311 "

Yielded no gas.

CONNERSVILLE.

SECTION OF WELL NO. 1.

Drift, Hudson River and Utica	712 feet.
Trenton limestone	522 "
Potsdam sandstone	12 "
Total depth	1,246 feet.
Trenton above sea level	120 "

Yielded a small flow of gas.

CONNERSVILLE.

SECTION OF WELL NO. 2.

Drift	90 feet.
Hudson River and Utica	615 "
Trenton limestone	61 "
Total depth	766 feet.
Trenton above sea level	117 "

Yielded small flow of gas.

CRAWFORDSVILLE.

SECTION OF WELL NO. 1.

Drift	140 feet.
Sub-Carboniferous rocks	410 "
Devonian shale	80 "
Corniferous limestones	55 "
Niagara limestones	380 "
Hudson River and Utica	365 "
Trenton limestone	69 "
Total depth	1,499 feet.
Trenton below sea level	664 "

Yielded no gas.

DECATUR.

Section of Well No. 1.

Drift	39 feet.
Water-lime and Niagara limestone	480 "
Hudson River and Utica	511 "
Trenton limestone	10 "
Total depth	1,040 feet.
Trenton below sea level	223 "

Yielded no gas.

DELPHI.

Section of Well No. 1.

Niagara limestone	587 feet.
Hudson River limestone and shale	220 "
Utica shale	93 "
Trenton limestone	12 "
Total depth	912 feet.
Trenton below sea level	334 "

Yielded no gas.

DELPHI.

Section of Well No. 2.

Niagara limestone	565 feet.
Hudson River and Utica shale	351 "
Trenton limestone	434 "
Potsdam sandstone	12 "
Total depth	1,362 feet.
Trenton below sea level	350 "

Yielded no gas.

DELTA, OHIO.

Section of Well No. 1.

Drift	117 feet.
Devonian shale	133 "
Devonian limestone	45 "
Water-lime and Niagara limestone	737 "
Hudson River and Utica	1,030 "
Trenton limestone	239 "
Total depth	2,301 feet.
Trenton below sea level	1,241 "

Moderate flow of gas.

DUNKIRK.

Section of Well No. 1.

Drift	60 feet.
Niagara limestone	230 "
Hudson River and Utica	640 "
Trenton limestone	25 "
Total depth	955 feet.
Trenton above sea level	39 "

Yielded very strong flow of gas.

In this well gas is found in the shale of a depth of 462 feet, which burns from the well head, making a flame eight feet high.

ELKHART.

Section of Well No. 1.

Drift	122 feet.
Sub-Carboniferous shale (gray shale)	213 "
Hamilton black shale	215 "
Corniferous limestone	65 "

At this depth the well was abandoned, under the erroneous belief that the drill had passed through the Hudson River and Utica shales, and that the Corniferous was Trenton limestone.

ELWOOD.

Section of Well No. 1.

Drift	106 feet.
Limestone and shales	834 "
Trenton limestone	8 "
Total depth	948 feet.

Yielded strong flow of gas.

ELWOOD.

Section of Well No. 2.

Drift	54 feet.
Niagara limestone	270 "
Hudson River limestone and shale	260 "
Utica shale	340 "
Trenton limestone	16 "
Total depth	940 feet.
Trenton below sea level	66 "

Yielded strong flow of gas.

FAIRMONT.

Section of Well No. 1.

Drift	35 feet.
Niagara limestone	309 "
Hudson River and Utica.	590 "
Trenton limestone.	31 "
Total depth	965 feet.
Trenton below sea level	41 "

Yielded very strong flow of gas.

FAIRMONT.

Section of Well No. 2.

Drift	17 feet.
Niagara limestone and shale	305 "
Hudson River and Utica.	588 "
Trenton limestone.	54 "
Total depth	964 "
Trenton below sea level	23 "

Yielded very strong flow of gas.

FARMLAND.

Section of Well No. 1.

Drift.	55 feet.
Niagara limestone.	160 "
Hudson River limestone and shale	585 "
Utica shale.	185 "
Trenton limestone.	32 "
Total depth	1,017 feet.
Trenton above sea level	55 "

A good flow of gas was found at a depth of 995 feet.

FT. WAYNE.

Section of Well No. 1. Finished Nov. 18, 1886.

Drift	77 feet.
Water-lime.	30 "
Niagara	570 "
Hudson River and Utica	751 "
Trenton limestone	15 "
Total depth	1,443 feet.
Trenton below sea level	693 "

Gas with an initial pressure of 160 pounds to the square inch was found upon reaching Trenton rock at a depth of 1,428 feet; at a depth of 1,431 feet a considerable quantity of oil was found.

FT. WAYNE.

Section of Well No. 2.

Drift	110 feet.
Lower Helderberg	34 "
Niagara limestone and shale	571 "
Hudson River limestone and shale	410 "
Utica shale	312 "
Trenton limestone	21 "
Total depth	1,458 feet.
Trenton below sea-level	650 "

Yielded no gas. Salt water, however, was found in considerable quantities.

FT. WAYNE.

Section of Well Bored on Section 4, Township 32, Range 12, Perry Township, Allen County, by Prof. Dryer.

Surface above sea level	844 feet.
Drift	281 "
Limestone	749 "
White shale	430 "
Black shale	240 "
Trenton limestone	52 "
Total depth	1,752 feet.
Trenton below sea level	856 "

Did not strike gas, oil nor salt water.

FOWLER.

Section of Well No. 1.

Drift	280 feet.
Devonian black shale	92 "
Corniferous limestone	40 "
Niagara limestone	328 "
Hudson River and Utica	255 "
Total depth	995 feet.
Trenton below sea level	181 "

Did not yield gas.

FRANCISVILLE.

Section of Well No. 1.

Drift	8 feet.
Niagara limestone	542 "
Hudson River limestone and shale	235 "
Utica shale	100 "
Trenton limestone	10 "
Total depth	895 feet.
Trenton below sea level	200 "

Yielded a small quantity of gas.

Petroleum was found in the shales at a depth of 630 feet, which accumulated in the bore at the rate of about 25 barrels per day. The oil produced was a heavy grade, and made a fair lubricator upon actual test. Another stratum bearing oil occurred in the Trenton rock at a depth of 885 feet. The yield, however, being less than that from the stratum above.

FRANKFORT.

Section of Well No. 2.

Drift	278 feet.
Niagara limestone and shale	380 "
Trenton limestone	10 "
Hudson River and Utica	400 "
Trenton limestone	260 "
Total depth	1,328 feet.
Trenton below sea level	227 "

Yielded no gas.

FRANKTON.

Section of Well No. 1.

Drift	88 feet.
Niagara limestone and shale	272 "
Hudson River and Utica	480 "
Trenton limestone	22 "
Total depth	862 feet.

Yielded good flow of gas.

GALVESTON.

Section of Well No. 1.

Drift	40 feet.
Corniferous and Niagara limestone	410 "
Hudson River and Utica	480
Trenton limestone	20 "
Total depth	950 feet.

Yielded no gas.

GARRETT.

Section of Well No. 1.

Depth to Trenton	1,980 feet.
Total depth	2,160 "
Trenton below sea level	1,098 "

Yielded small flow of gas.

GOSHEN.

Section of Well No. 2.

Drift	165 feet.
Shale, Sub-Carboniferous and Devonian	308 "
Corniferous limestone	60 "
Water-lime	32 "
Niagara limestone	728 "
Hudson River limestone and shale	307 "
Utica shale	215 "
Trenton limestone	239 "
Total depth	2,054 feet.
Trenton below sea level	1,026 "

Yielded no gas.

GREENFIELD.

Section of Well No. 1.

Drift	205 feet.
Niagara limestone	170 "
Hudson River and Utica	610 "
Trenton limestone	14 ft. 6 in.
Total depth	999 ft. 6 in.
Trenton below sea level	54 feet.

Yielded very strong flow of gas.

GREENSBURG.

Section of Well No. 1.

Drift	7 feet.
Niagara limestone	90 "
Hudson River limestone and shale	713 "
Utica shale	110 "
Trenton limestone	63 "
Total depth	983 feet.
Trenton above sea level	22 "

This well yielded a small flow of gas.

HARTFORD CITY.

Section of Well No. 1.

Drift	130 feet.
Niagara limestone	350 "
Hudson River and Utica	473 "
Trenton limestone	30 "
Total depth	983 feet
Trenton below sea level	70 "

Yielded strong flow of gas.

HARTFORD CITY.

Section of Well No. 2.

Drift	82 feet.
Niagara limestone	280 "
Hudson River limestone and shale	433 "
Utica shale	140 "
Trenton limestone	32 "
Total depth	967 feet.
Trenton below sea level	40 "

Yielded very strong flow of gas.

HAUGHVILLE.

Section of Well No. 1.

Drift	123 feet.
Corniferous and Niagara limestone	300 "
Hudson River and Utica	532 "
Trenton limestone	127 "
Total depth	1,082 feet.
Trenton below sea level	224 "

Yielded no gas.

HICKSVILLE, OHIO.

Section of Well No. 1.

Drift	142 feet.
Devonian shale	16 "
Devonian and Upper Silurian limestone	802 "
Hudson River and Utica	624 "
Trenton limestone	159 "
Total depth	1,743 feet.
Trenton below sea level	822 "

Yielded good flow of gas.

HUNTINGTON.

Section of Well No. 1, Drilled Just South of Wabash River.

Soil	2 feet.
Niagara limestone	398 "
Hudson River limestone and shale	275 "
Utica shale	320 "
Trenton limestone	39 "
Total depth	1,034 feet.
Trenton below sea level	255 "

Yielded no gas.

HUNTINGTON.

Section of Well No. 2, Drilled 2½ Miles East of the City, on the North Side of the River.

Niagara limestone and shale	431 feet.
Hudson River limestone and shale	266 "
Utica shale	315 "
Depth to Trenton limestone	1,012 feet.
Altitude of well	765 "
Trenton below sea level	247 "

Yielded no gas.

JEFFERSONVILLE.

Section of Well No. 1.

Alluvium	45 feet.
Devonian limestone	40 "
Niagara limestone	105 "
Clinton (?) limestone	20 "
Hudson River limestone and shale	646 "
Depth to Trenton	856 feet.
Trenton below sea level	401 "

Yielded small flow of gas.

JONESBORO.

Section of Well No. 1.

Drift	162 feet.
Niagara limestone	148 "
Hudson River limestone and shale	405 "
Utica shale	197 "
Trenton limestone	23 "
Total depth	935 feet.
Trenton below sea level	72 "

Yielded strong flow of gas.

KENTLAND.

Section of Well No. 1.

Drift	100 feet.
Black shale	100 "
Corniferous	45 "
Niagara limestone	305 "
Hudson River limestone	300 "
Utica shale	210 "
Clinton (?)	60 "
Total depth	1,120 feet.
Trenton below sea level	379 "

Yielded no gas.

KEWANA.

Section of Well No. 1.

Drift	170 feet.
Limestone and shale	879 feet.
Trenton limestone	29 "
Total depth	1,078 feet.
Trenton below sea level	278 "

Did not yield gas nor oil.

KNIGHTSTOWN.

Section of Well No. 1.

Drift	64 feet.
Niagara limestone	200 "
Hudson River limestone and shale	360 "
Utica shale	199 "
Trenton limestone	213 "
Total depth	1,036 feet.
Trenton above sea level	113 "

Well yielded a good flow of gas.

KOKOMO.

Section of Well No. 4.

Drift.	61 feet.
Water-lime and Niagara.	359 "
Hudson River limestone and shale	265 "
Utica shales	251 "
Trenton limestone.	22 "
Total depth.	958 feet.
Trenton below sea level	97 "

Yielded strong flow of gas.

LAFOUNTAINE.

Section of Well No. 1.

Drift	300 feet.
Niagara limestone	225 "
Hudson River limestone and shale	175 "
Utica shale	200 "
Trenton limestone	23 "
Total depth	923 feet.
Trenton below sea level	6 "

Yielded very strong flow of gas.

LAWRENCE.

Section of the Dunn Well.

Drift	188 feet.
Niagara limestone	272 "
Hudson River and Utica	455 "
Trenton limestone	40 "
Total depth	955 feet.

Yielded moderate flow of gas.

LAWRENCE.

Section of Kimberly Well.

Drift	161 feet.
Niagara limestone	207 "
Hudson River and Utica	476 "
Trenton limestone	22 "
Total depth	876 feet.

Yielded a good flow of gas.

LAWRENCEBURG.

Section of Well No. 1.

(This well was drilled in the river bottom.)

Alluvium	139 feet.
Hudson River limestone and shale	185 "
Utica shale	25 "
Trenton limestone	451 "
Potsdam sandstone	40 "
Total depth	840 feet.
Trenton above sea level	158 "

Yielded a small quantity of gas.

Well No. 2, drilled in the fair grounds, of which no accurate record was received at this office, yielded when first drilled 1,220,000 cubic feet of gas daily.

LEBANON.

Section of Well No. 1.

Total depth	1,800 feet.
Depth to Trenton	1,227 "
Trenton below sea level	302 "

Yielded no gas.

LOGANSPORT.

Section of Well No. 1.

Depth to Trenton	995 feet.
Trenton below sea level	344 "

Yielded no gas.

MARION.

Section of Well No. 3.

Drift	70 feet.
Niagara limestone	280 "
Hudson River and Utica	528 "
Trenton limestone	22 "
Total depth	900 feet.
Trenton below sea level	67 "

Yielded very strong flow of gas.

MARTINSVILLE.

Section of Well No. 1.

Drift	85 feet.
Sub-Carboniferous rocks	323 "
Hamilton shale	120 "
Corniferous limestone	62 "
Niagara limestone	236 "
Hudson River and Utica	571 "
Trenton limestone	51 "
Total depth	1,448 feet.
Trenton below sea level	780 "

Yielded no gas.

MONTICELLO.

Section of Well No. 1.

Drift	205 feet.
Niagara limestone	515 "
Hudson River limestone and shale	120 "
Utica shale	170 "
Trenton limestone	63 "
Total depth	1,073 feet.
Trenton below sea level	338 "

Yielded no gas.

MONTPELIER.

Section of Well No. 1.

Drift	17 feet.
Niagara limestone and shale	233 "
Hudson River limestone and shale	432 "
Utica shale	280 "
Trenton limestone	19 "
Total depth	981 feet.
Trenton below sea level	110 "

Yielded good flow of gas and about twenty-five barrels of petroleum per day.

MORRISTOWN.

Section of Muth Well.

Drift	140 feet.
Niagara limestone	130 "
Hudson River limestone and shale	550 "
Utica shale	78 "
Trenton limestone	23 "
Total depth	921 feet.
Trenton below sea level	44 "

Yielded good flow of gas.

NEW ALBANY.

Section of Well No. 1.

Clay and Sub-Carboniferous shale	80 feet.
Devonian shale	104 "
Corniferous limestone	69 "
Niagara limestone	209 "
Hudson River and Utica	545 "
Trenton limestone	500 "
Total depth	1,507 feet.

Yielded no gas.

NEW CASTLE.

Section of Well No. 1.

Drift	333 feet.
Hudson River shales	200 "
Utica shale	343 "
Trenton limestone	421 "
Total depth	1,297 feet.
Trenton above sea level	104 "

Yielded a small flow of gas.

NEW CASTLE.

Section of Well No. 2.

Drift	243 feet.
Niagara limestone	5 "
Hudson River limestone and shale	452 "
Utica shale	235 "
Trenton limestone	78 "
Total depth	1,013 feet.
Trenton above sea level	120 "

Yielded medium flow of gas.

NOBLESVILLE.

Section Banner Well.

Drift	73 feet.
Niagara limestone and shale	265 "
Clinton (?) limestone	30 "
Hudson River and Utica	476 "
Trenton limestone	9 "
Total depth	853 feet.
Trenton below sea level	76 "

Yielded strong flow of gas.

NOBLESVILLE.

Section Mallory Well.

Depth of Trenton rock	865 feet.
Trenton below sea level	85 "

Yielded very strong flow of gas.

NORTH MANCHESTER.

Section of Well No. 1.

Drift	274 feet.
Niagara limestone and shale	300 "
Hudson River limestone and shale	250 "
Utica shale	306 "
Trenton limestone	50 "
Total depth	1,180 feet.
Trenton below sea level	355 "

Yielded no gas.

NORTH VERNON.

SECTION OF WELL NO. 1.

Surface clay	11 feet.
Corniferous limestone	28 "
Niagara limestone.	252 "
Clinton (?) limestone	29 "
Hudson River limestone	440 "
Utica shale.	220 "
Trenton limestone.	470 "
Total depth	1,450 feet.
Trenton below sea level	253 "

Yielded medium flow of gas.

OXFORD.

SECTION OF WELL NO. 1.

Drift	385 feet.
Devonian shale	100 "
Limestone	115 "
White shale	100 "
Hard limestone	300 "
Limestone and shale	85 "
Utica shale.	188 "
Depth to Trenton	1,273 feet.
Trenton below sea level	570 "

Yielded no gas.

PERU.

SECTION OF WELL NO. 1.

Drift	36 feet.
Niagara (and Clinton ?) limestone	385 "
Hudson River and Utica	454 "
Trenton limestone.	30 "
Total depth.	905 feet.
Trenton below sea level	218 "

A small quantity of oil was found at a depth of 808 feet. Salt water occurred at 900 feet. This well was bored in the Northern part of the city.

PERU.

SECTION OF WELL NO. 2.

Drift	10 feet.
Water-lime and Niagara limestone	455 "
Clinton (?) limestone	15 "
Hudson River and Utica.	449 "
Trenton limestone.	27 "
Total depth.	956 feet.
Trenton below sea level	229 "

Yields a small quantity of gas and oil, but not sufficient for use.

This well was bored a little south of the city limits, about 1¼ miles from well No. 1.

PERU.

SECTION OF WELL No. 3.

(Situated on Younce farm, 7 miles southeast of Peru.)

Drift	70 feet.
Niagara limestone	490 "
Hudson River and Utica	400 "
Trenton limestone	42 "
Total depth	1,002 feet.

A light flow of gas was obtained from this well.

At a depth of 1,000 feet salt water was struck, which raised to the surface.

PERU.

SECTION OF WELL No. 4.

(Located on Bearss farm, 2½ miles north of city.)

Drift	324 feet.
Niagara limestone	276 "
Hudson River and Utica	407 "
Trenton limestone	35 "
Total depth	1,042 feet.

Yielded no gas.

Salt water was struck at the depth of 1,042 feet, which raised to within 50 feet of the surface.

PORTER STATION.

SECTION OF WELL No. 1.

Sub-Carboniferous and Devonian rocks	280 feet.
Niagara limestone and shale	350 "
Hudson River and Utica	498 "
Depth to Trenton	1,128 feet.
Trenton below sea level	548 "

Yielded no gas.

PORTLAND.

The following facts, relating to the Portland gas wells, were obtained from Prof. Elwood Haynes, Superintendent gas company, of Portland:

WELL No. 2.

Depth to Trenton	982.2 feet.
Altitude of surface	919.9 "
Trenton below sea level	63.3 feet.

WELL No. 3.

Depth to Trenton	981.3 feet.
Altitude of surface	922 "
Trenton below sea level	59.3 feet.

WELL No. 4.

Depth to Trenton	986.4 feet.
Altitude of surface	918.8 "
Trenton below sea level	67.6 feet.

WELL No. 5.

Depth to Trenton	984.8 feet.
Altitude of surface	918.8 "
Trenton below sea level	66 feet.

The following analysis of Trenton limestone, taken from a well at Portland, was made by Prof. Haynes, and kindly furnished this office:

Carbonate magnesia	0.32
Calcium carbonate	0.63
Carbonaceous matter	0.02
Iron	0.01
Aluminum	0.01
Water	0.01
Total	1.00

RED KEY.

SECTION OF WELL No. 1.

Drift	72 feet.
Niagara limestone	143 "
Hudson River limestone and shale	415 "
Utica shale	350 "
Trenton limestone	48 "
Total depth	1,028 feet.
Trenton below sea level	90 "

Yielded strong flow of gas.

REMINGTON.

SECTION OF WELL No. 1.

Drift	5 feet.
Devonian shale	85 "
Corniferous limestone	50 "
Niagara limestone	260 "
Hudson River and Utica	570 "
Trenton limestone	295 "
Total depth	1,265 feet.

Yielded no gas.

RICHMOND.

SECTION OF WELL NO. 1.

Hudson River limestone and shale	500 feet.
Utica shale	380 "
Trenton limestone	510 "
Potsdam sandstone	10 "
Total depth	1,400 feet.
Altitude of well	959 "
Trenton above sea level	79 "

Yielded no gas.

RIDGEVILLE.

SECTION OF WELL NO. 1.

Drift	30 feet.
Niagara limestone	212 "
Hudson River and Utica	739 "
Trenton limestone	167 "
Total depth	1,148 feet.
Trenton above sea level	1 foot.

Did not yield gas.

ROCHESTER.

SECTION OF WELL NO. 1.

Drift	245 feet.
Niagara limestone	525 "
Hudson River and Utica	391 "
Trenton limestone	24 "
Total depth	1,185 feet.
Trenton below sea level	351 "

Yielded no gas.

ROCKVILLE.

SECTION OF WELL NO. 1.

Drift	96 feet.
Gray sandstone	44 "
Brown shale	25 "
White sandstone	110 "
White shale	25 "
Black shale	105 "
White sandstone	50 "
Limestone	170 "
Gray shale	305 "

ROCKVILLE—SECTION OF WELL No. 1—Continued.

Sandstone	100 feet.
White shale	114 "
Black shale	102 "
Limestone	118 "
Brown sandstone	46 "
White limestone	135 "
Crystallized limestone	85 "
White shale, like Kaolin	48 "
Limestone	108 "
Dark shale (Utica)	324 "
Total depth to Trenton	2,100 feet.
Altitude of well	688 "
Trenton below sea level	1,412 "

Yielded no gas.

ROYAL CENTRE.

SECTION OF WELL No. 1.

Drift	109 feet.
Niagara limestone	486 "
Hudson River and Utica	330 "
Trenton limestone	42 "
Total depth	967 feet.
Trenton below sea level	190 "

Yielded small quantity of gas and twenty-five barrels of oil per day.

RUSHVILLE.

SECTION OF WELL No. 1. RECORD KEPT BY MR. GEO. C. CLARK.

Drift	60 feet.
Chert and cherty limestone (Corniferous)	40 "
Niagara limestone and shale	200 "
Hudson River limestone and shale	200 "
Utica shale	360 "
Total depth to Trenton	860 feet.
Altitude of well, accurately leveled	$948\frac{41}{100}$ feet.
Trenton above sea level	$124\frac{41}{100}$ "

Yielded a small flow of gas.

SALEM.

Section of Well No. 1.

Soil	7 feet.
Keokuk limestone	53 "
Sub-Carboniferous sandstone	567 "
Hamilton shale	103 "
Devonian limestone	40 "
Niagara limestone	215 "
Clinton (?) limestone	30 "
Hudson River limestone and shale	535 "
Utica shale	180 "
Trenton limestone	45 "
Total depth	1,775 feet.
Trenton below sea level	1,000 "

Yielded good flow of gas. The gas was found in the limestone underlying Devonian shale.

SEYMOUR.

Section of Well No. 1.

Drift	75 feet.
Sub-Carboniferous sandstone	15 "
Devonian sandstone	115 "
Corniferous limestone	20 "
Niagara limestone	190 "
Hudson River limestone and shale	520 "
Utica shale	165 "
Trenton limestone	94 "
Total depth	1,194 feet.
Trenton below sea level	472 "

Yielded no gas.

SHELBYVILLE.

Section of Well No. 1.

Drift	48 feet.
Corniferous limestone	30 "
Niagara limestone and shale	102 "
Hudson River limestone and shale	657 "
Trenton limestone	86 "
Total depth	923 feet.
Trenton below sea level	79 "

Yielded small flow of gas.

SHELBYVILLE.

Section of Well No. 2.

Drift	80 feet.
Limestone and shale	769 "
Total depth to Trenton	849 feet.

Yielded small flow of gas.

SOUTH BEND.

Section of the Studebaker Well.

Drift	160 feet.
Sub-Carboniferous and Hamilton shale	220 "
Corniferous limestone	60 "
Lower Helderberg limestone	40 "
Niagara limestone	640 "
Clinton (?) limestone	60 "
Hudson River and Utica	420 "
Trenton limestone	427 "
Total depth	2,027 feet.
Trenton below sea level	855 "

Yielded no gas nor oil.

SPICELAND.

Section of Well No. 1.

Trenton rock reached at a depth of	940 feet
Considerable flow of gas was found at	943 "
Total depth of well	968 "
Trenton above sea level	85 "

A good flow of gas.

SUMMITVILLE.

Section of Well No. 1.

Drift	100 feet
Niagara limestone	236 "
Hudson River limestone and shale	300 "
Utica shale	292 "
Trenton limestone	50 "
Total depth	978 feet
Trenton below sea level	32 "

Yielded very strong flow of gas.

TERRE HAUTE.

Section of White Sulphur, Artesian Well.

Sand and gravel	150 feet.	
Fire-clay	1 "	6 in.
Brown slate	2 "	
Soapstone	11 "	
Coal	4 "	
Fire-clay	3 "	6 in.
Limestone	2 "	1 "
Fire-clay	3 "	2 "
Brown limestone	2 "	
Soapstone	1 "	6 in.
Coal		6 "
Fire-clay	3 feet,	2 "
Limestone	2 "	6 "
Hard-pan	8 "	6 "
Soapstone	10 "	5 "
Coal	2 "	
Fire-clay	3 "	
Sandstone	1 "	
Blue limestone	2 "	4 in.
Dark blue rock	2 "	6 "
White sandstone	3 "	
Fire-clay	5 "	
Shale	2 "	4 in.
Soapstone	2 "	
Blue limestone	5 "	2 in.
Soapstone	5 "	
Black shale	4 "	
Blue sandstone	6 "	
Black shale	2 "	
Fire-clay	5 "	
Gray sandstone	10 "	
Coal		9 in.
Fire-clay	2 feet,	5 "
Blue rock	3 "	4 "
Black shale	3 "	
Fire-clay	2 "	3 in.
Limestone	4 "	
Fire-clay	5 "	10 in.
Limestone	3 "	6 "
Coal	2 "	6 "
Fire-clay	1 "	
Sandstone	28 "	3 in.
Fire-clay	7 "	2 "
Blue sandstone	27 "	
Slate	9 "	
Blue sandstone	29 "	1 in.
White sandstone	8 "	

TERRE HAUTE—SECTION OF WHITE SULPHUR, ARTESIAN WELL—Continued.

Slate	36 feet,	2½ in.
Sandstone	1 "	7½ "
Blue slate	15 "	9 "
White slate	10 "	2 "
White sandstone	35 "	11½ "
Soapstone	43 "	
Blue slate	28 "	7½ in.
White slate	7 "	7 "
Hard sandstone	23 "	9 "
Hard black stone	9 "	6 "
White slate	12 "	
Hard sand rock	127 "	
White limestone	4 "	4 in.
White fire-clay	3 "	3 "
White limestone	30 "	
Hard gray sandstone	10 "	
Blue limestone	6 "	11 in.
Hard white sandstone		9 "
Hard blue sandstone	3 feet,	6 "
Blue clay	3 "	
Hard gray sandstone	2 "	3½ in.
Hard blue sandstone	3 "	3 "
Hard sandstone	110 "	5 "
Soft sandstone	7 "	3 "
Blue slate	5 "	
Blue hard sandstone	411 "	2 in.
Blue soapstone	34 "	10 "
White grit sandstone	117 "	2 "
Hard blue slate	48 "	
Brown sandstone	89 "	11 in.
Coarse white sandstone	6 "	9 "
Yellow sandstone	44 "	2 "
Hard flint	15 "	8 "
Clay, limestone and shale	70 "	2 "

At a depth of 840 feet, a show of oil was found; at a depth of 1,296 feet 9 inches, lubricating oil was found; at a depth of 1,335 feet, a vein of fresh water was found; at a depth of 1,620 feet 10 inches, a vein of oil was found; at a depth of 1,658 feet, blue sulphur water was found; at a depth of 1,710 feet, white sulphur water was found; at a depth of 1,768 feet, more white sulphur water was found; at a depth of 1,785 feet, a large flow of white sulphur water, yielding at the rate of 6,000 gallons per hour, was found.

THORNTOWN.

SECTION OF WELL No. 1.

Drift.	65 feet.
Sub-carboniferous limestone and shale.	238 "
Hamilton shale.	87 "
Corniferous limestone	37 "
Niagara limestone.	407 "
Hudson River and Utica.	373 "
Trenton limestone.	80 "
Total depth.	1,287 feet.
Trenton below sea level	394 "

Yielded no gas.

TOBACCO LANDING.

SECTION OF WELL No. 1.

Keokuk limestone.	15 feet.
Knobstone	390 "
Depth to Devonian shale.	405 feet.

A good flow of gas was found in Devonian shale.

UNION CITY.

SECTION OF WELL No 1.

Drift.	98 feet.
Niagara limestone.	250 "
Hudson River and Utica.	800 "
Trenton limestone.	540 "
Total depth.	1,688 feet.
Trenton below sea level	40 "

Traces of gas were observed from a depth of 1,155 to 1,162 feet.

UNION CITY.

SECTION OF WELL No. 2.

Drift.	70 feet.
Niagara limestone and shale	210 "
Clinton (?) limestone	10 "
Hudson River limestone and shale	510 "
Utica shale.	340 "
Total depth.	1,140 feet.

At the time this record was obtained the well was not yet completed.

VALPARAISO.

Section of Well No. 1.

Drift	125 feet.
Hamilton shale	65 "
Corniferous limestone	55 "
Niagara limestone	565 "
Clinton (?) limestone	10 "
Hudson River limestone and shale	185 "
Utica shale	295 "
Trenton limestone	144 "
Total depth	1,444 feet.
Trenton below sea level	602 "

Did not yield gas.

VINCENNES ARTESIAN SALT WELL.

Sand and gravel	80 feet.
Sandstone	18 "
Soapstone	100 "
Hard pebble rock	10 "
Sandy shale	15 "
Soapstone	32 "
Blue sandstone	35 "
Sandy shale	20 "
Soapstone	10 "
Coal	3 "
Soapstone	18 "
Coal	5 "
Soapstone	18 "
Black shale	41 "
Soapstone	138 "
Coal	5 "
Limestone	10 "
Blue shale	47 "
Black slate	30 "
Soapstone and shale	80 "
Sandstone	15 "
Slate and soapstone	75 "
Sandstone and salt water	25 "
Slate and shale	95 "
Sandstone	175 "
Shale and black slate	140 "
Sandstone	96 "
Total depth	1,336 feet.

WABASH.

SECTION OF WELL NO. 2, FROM RECORD KEPT BY DR. FORD, OF WABASH.

Drift	28 feet.
Niagara limestone and shale	525 "
Hudson River and Utica	325 "
Trenton limestone	54 "
Total depth	932 feet.
Trenton below sea level	198 "

Did not yield gas nor oil.

WARSAW.

SECTION OF WELL NO. 1.

Drift	248 feet.
Niagara limestone	652 "
Hudson River and Utica	487 "
Trenton limestone	77 "
Total depth	1,464 feet.
Trenton below sea level	570 "

Yielded no gas.

WINCHESTER.

SECTION OF WELL NO. 1.

Drift	147 feet.
Niagara limestone	71 "
Hudson River limestone and shale	582 "
Utica shale	250 "
Trenton limestone	90 "
Total depth	1,140 feet.
Trenton above sea level	43 "

Gas is found in Hudson River shales at a depth of 730 feet, and also in Trenton limestone, the yield in each instance, however, being small.

Petroleum is found in Trenton limestone, which accumulated in the well at a rate of about four barrels per day.

WINCHESTER.

SECTION OF WELL NO. 2.

Drift	131	feet.
Niagara limestone	69	"
Hudson River limestone and shale	575	"
Utica shale	240	"
Trenton limestone	95	"
Total depth	1,110	feet.
Altitude of the surface at the well, leveled	$1,068\frac{5}{10}$	"
Depth to Trenton	1,015	"
Trenton above sea level	$53\frac{5}{10}$	feet.

A good flow of gas was found at a depth of 1,029 feet. A cartridge of nitro-glycerine was exploded in the well, which increased the flow of gas materially, after which several barrels of oil were taken from the well.

WINCHESTER.

Section of Well No. 3.

Drift	116	feet.
Niagara limestone	76	"
Hudson River and Utica	816	"
Trenton limestone	120	"
Total depth	1,128	feet.
Altitude of well	$1,076\frac{5}{10}$	"
Depth to Trenton	1,008	"
Trenton above sea level	$68\frac{5}{10}$	feet.

Gas was found at a depth of 1,036 feet. Oil in considerable quantities after "shooting" the well.

XENIA.

Section of Well No. 1.

Drift	50	feet.
Water-lime	31	"
Niagara limestone	238	"
Hudson River and Utica	587	"
Trenton limestone	31	"
Total depth	937	feet.
Trenton below sea level	91	"

Yields a good flow of gas, though volume not ascertained.

The wells described above are scattered pretty generally over the State. There are several counties, however, where no deep wells have yet been drilled, or if they have been, no information has reached the State Geologist concerning them. In a considerable number of counties only one or two wells have been drilled.

Prospectors for gas, oil or other substances frequently write the State Geologist asking for information as to the probable depth to Trenton limestone in a particular locality. For general information upon that subject, the following estimate of the approximate altitude of Trenton limestone, as compared with sea level, is inserted. By finding the altitude of the surface at the well, it will be a matter of small difficulty to determine to within a short distance the depth to Trenton rock in any county in the State. To further aid in forming a conclusion in this matter, a table of altitudes is given, showing the height above the sea of all the important points in the State of which we have data. The altitude of the surface at the well in any part of the State may be ascertained by taking the nearest point given in the table of altitudes, and leveling from that point to the location of the proposed well. When the altitude is known it is easy to estimate the approximate depth of Trenton limestone.

Approximate depth, above or below sea level, of the Trenton limestones in the different counties of Indiana:

Counties.	Sea Level.	Feet.
Adams	Below	200 to 400
Allen	Below	400 to 800
Bartholomew	Below	300 to 350
Benton	Below	350 to 600
Blackford	Below	40 to 120
Boone	Below	350 to 500
Brown	Below	600 to 800
Carroll	Below	225 to 300
Cass	Below	150 to 300
Clark	Below	500 to 600
Clay	Below	1,300 to 1,400
Clinton	Below	300 to 500
Crawford	Below	750 to 850
Daviess	Below	1,200 to 1,300
Dearborn	Above	150 to 175
Decatur	Above	10 to 100
Dekalb	Below	1,000 to 1,200
Delaware	Above	0 to 75
Dubois	Below	850 to 1,000
Elkhart	Below	1,150 to 1,350
Fayette	Above	100 to 150
Floyd	Below	600 to 750
Fountain	Below	600 to 800
Franklin	Above	125 to 175
Fulton	Below	400 to 700
Gibson	Below	1,400 to 1,600
Grant	Below	50 to 100
Greene	Below	1,100 to 1,200
Hamilton	Below	50 to 100
Hancock	Below	20 to 80
Harrison	Below	750 to 800
Hendricks	Below	350 to 500
Henry	Above	0 to 125
Howard	Below	40 to 150
Huntington	Below	200 to 400
Jackson	Below	300 to 350
Jasper	Below	150 to 250
Jay	Below	0 to 100
Jefferson	Below	250 to 500
Jennings	Below	150 to 300
Johnson	Below	350 to 600
Knox	Below	1,300 to 1,600
Kosciusko	Below	1,000 to 1,350
Lagrange	Below	1,250 to 1,400
Lake	Below	300 to 400
Laporte	Below	400 to 500
Lawrence	Below	700 to 850

Counties.	Sea Level.	Feet
Madison	Above, 65 feet, to 50 feet below.	
Marion	Below	110 to 450
Marshall	Below	700 to 1,100
Martin	Below	850 to 1,200
Miami	Below	100 to 350
Monroe	Below	1,000 to 1,150
Montgomery	Below	600 to 700
Morgan	Below	750 to 900
Newton	Below	200 to 300
Noble	Below	1,200 to 1,300
Ohio	Above	100 to 150
Orange	Below	750 to 850
Owen	Below	900 to 1,000
Parke	Below	1,400 to 1,500
Perry	Below	850 to 950
Pike	Below	1,250 to 1,350
Porter	Below	400 to 600
Posey	Below	1,500 to 1,700
Pulaski	Below	200 to 450
Putnam	Below	500 to 800
Randolph	Above	0 to 100
Ripley	Above, 50 feet, to 100 feet below.	
Rush	Above, 125, to 0 feet below.	
Scott	Below	350 to 500
Shelby	Below	50 to 300
Spencer	Below	950 to 1,200
Starke	Below	350 to 700
Steuben	Below	1,400 to 1,500
Sullivan	Below	1,300 to 1,600
Switzerland	Above	0 to 75
Tippecanoe	Below	500 to 600
Tipton	Below	75 to 180
Union	Above	100 to 150
Vanderburgh	Below	1,300 to 1,500
Vermillion	Below	1,400 to 1,600
Vigo	Below	1,400 to 1,600
Wabash	Below	10 to 350
Warren	Below	600 to 750
Warrick	Below	1,200 to 1,350
Washington	Below	500 to 750
Wayne	Above	75 to 175
Wells	Below	200 to 400
White	Below	200 to 350
Whitley	Below	400 to 800

TABLE OF ALTITUDES IN INDIANA.

	Authority.	*Altitude.*
ADAMS COUNTY—		
Decatur	C., R. & Ft. W. R. R	807 feet.
ALLEN COUNTY—		
Arcola	P., Ft. W. & C. R. R	833 feet.
Fort Wayne	G. R. & Ind. R. R	752 "
"	P., Ft. W. & C. R. R	775 "
"	City datum, City Engineer	762 "
Huntertown	G. R. & Ind. R. R.	827 "
New Haven.	T., W. & W. R. R	753 "
Wallen.	G. R. & Ind. R. R	839 "
Woodburn	T., W. & W. R. R	750 "
BARTHOLOMEW COUNTY—		
Clifford.	J., M. & I. R. R	664 feet.
Columbus.	J., M. & I. R. R	630 "
Elizabethtown	J., M. & I. R. R	646 "
Jonesville	J., M. & I. R. R	595 "
St. Louis Crossing	J., M. & I. R. R	683 "
Taylorsville	J., M. & I. R. R	656 "
Wailesborough	J., M. & I. R. R	613 "
Waynesville	J., M. & I. R. R	607 "
BENTON COUNTY—		
Ambia	L. E. & W. R. R.	710 feet.
Boswell.	L. E. & W. R. R.	734 "
Chase	L. E. & W. R. R.	719 "
Earl Park	C., I., St. L. & C. R. R	814 "
Fowler	C., I., St. L. & C. R. R	823 "
Gravel Hill	Surface of Hill	857 "
Mt. Gilboa	Prof. Owen	815 "
Otterbein	L. E. & W. R. R.	785 "
Oxford	L. E. & W. R. R.	703 "
Raub.	C., I., St. L. & C. R. R	731 "
Talbot	L. E. & W. R. R.	710 "
Templeton	L. E. & W. R. R.	675 "
BLACKFORD COUNTY—		
Hartford City.	Ft. W., M. & C. R. R.	895 feet.
Montpelier	Ft. W., M. & C. R. R.	867 "

	Authority.	Altitude.
Boone County—		
Lebanon	C., I., St. L. & C. R. R	925 feet.
Thorntown	C., I., St. L. & C. R. R	813 "
Cass County—		
Adamsboro	Eel River R. R	665 feet.
Anoka	Pan Handle R. R	696 "
Curveton	T., P. & W. R. R	671 "
Lake Cicott.	T., P. & W. R. R.	703 "
Logansport	W., St. L. & P. R. R	606 "
Onward	Pan Handle R. R	763 "
Royal Centre	Pan Handle R. R	735 "
Clark County—		
Charleston	O. & M. R. R	589 feet.
Henryville	J., M. & I. R. R	479 "
Jeffersonville	O. & M. R. R.	455 "
Memphis	J., M. & I. R. R	490 "
New Providence	L., N. A. & C. R. R	551 "
Sellersburg	J., M. & I. R. R	478 "
Clay County—		
Brazil	T. H. & I. R. R	643 feet.
Clay City	T. H. & S. E. R. R	584 "
Cloverland	T. H. & I. R. R	577 "
Cory	T. H. & S. E. R. R	625 "
Harmony	T. H. & I. R. R.	672 "
Saline City	T. H. & S. E. R. R	555 "
Staunton	T. H. & I. R. R	643 "
Clinton County—		
Boyleston	L. E. & W. R. R.	896 feet.
Colfax	C., I., St. L. & C. R. R.	825 "
Frankfort.	L. E. & W. R. R.	841 "
Hillsburg	L. E. & W. R. R.	910 "
Jefferson	L. E. & W. R. R	827 "
Mulberry	L. E. & W. R. R.	754 "
Daviess County—		
Washington.	O. & M. R. R	484 feet.
Dearborn County—		
Aurora	O. & M. R. R	493 feet.
Cochran	O. & M. R. R	493 "
Guilford	C., I., St. L. & C. R. R	508 "
Lawrenceburgh	O. & M. R. R	479 "
Mooreshill	O. & M. R. R	916 "
Weisburg	C., I., St. L. & C	929 "
Decatur County—		
Adams	C., I., St. L. & C. R. R	880 feet.
Greensburg	C., I., St. L. & C. R. R	942 "
New Point	C., I., St. L. & C. R. R	981 "
St. Paul	C., I., St. L. & C. R. R	852 "

	Authority.	Altitude.
Dekalb County—		
Auburn	Ft. W., J. & S. R. R	872 feet.
"	Ft. W., J. & S. R. R. Junction	868 "
Butler	L. S. & M. S. R. R	863 "
Cedar Creek	Eel River R. R	861 "
Corunna	L. S. & M. S. R. R	937 "
New Era	Ft. W., J. & S. R. R	859 "
Summit	Ft. W., J. & S. R. R	1,001 "
Waterloo	Ft. W., J. & S. R. R	914 "
Delaware County—		
Daleville	C., C., C. & I. R. R	910 feet.
Eaton	Ft. W., M. & C. R. R. Track at Bridge	910 "
Muncie	C., C., C. & I. R. R	948 "
Reed	L. E. & W. R. R	936 "
Selma	C., C., C. & I. R. R	1,005 "
Yorktown	C., C., C. & I. R. R	924 "
Elkhart County—		
Bristol	L. S. & M. S. R. R	786 feet.
Elkhart	L. S. & M. S. R. R	755 "
"	C., W. & M. R. R	741 "
Goshen	L. S. & M. S. R. R	789 "
Millersburg	L. S. & M. S.	886 "
New Paris	C., W. & M. R. R	828 "
Vistula	L. S. & M. S. R. R	809 "
Fayette County—		
Bentonville	J., M. & I. R. R	1,056 feet.
Connersville	C., H. & D. R. R	832 "
Glenwood	C., H. & D. R. R	1,092 "
Longwood	C., H. & D. R. R	1,111 "
Salter's Switch	C., H. & D. R. R	919 "
Lyons	C., H. & D. R. R	896 "
Floyd County—		
New Albany	J., M. & I. R. R	438 feet.
"	Low Water, Ohio River	362 "
Galena		958 "
Fountain County—		
Attica	W., St. L. & P. R. R	540 feet.
"	T., W. & W. R. R	556 "
"	Low Water, Wabash River	516 "
Gibson County—		
Princeton	E. & T. H. R. R	483 feet.
Grant County—		
Fairmont	C., W. & M. R. R	893 feet.
Jonesboro	Panhandle R. R	846 "
Marion	Panhandle R. R	811 "
Mier	Panhandle R. R	816 "
Van Buren		950 "

	Authority.	Altitude.
Greene County—		
Dixon	Indianapolis & Vincennes R. R	530 feet.
Lyons	Indianapolis & Vincennes R. R	509 "
Marco	Indianapolis & Vincennes R. R	482 "
Switz City	Indianapolis & Vincennes R. R	526 "
Worthington	Indianapolis & Vincennes R. R	522 "
Hamilton County—		
Noblesville		770 feet.
Westfield	L., N. A. & C. R. R	786 "
Hancock County—		
Fortville	C., C., C. & I. R. R.	857 feet.
Greenfield	Panhandle R. R	906 "
McCordsville	C., C., C. & I. R. R.	854 "
Maxwells	I., B. & W. R. R	920 "
Mount Comfort	I., B. & W. R. R.	870 "
Sugar Creek	I., B. & W. R. R	855 "
Warrington	I., B. & W. R. R	1,020 "
Willow Branch	I., B. & W. R. R.	950 "
Hendricks County—		
Clayton	T. H. & I. R. R	890 feet.
Coatsville	T. H. & I. R. R	878 "
Danville	T. H. & I. R. R	613 "
Friendsville	Indianapolis & Vincennes R. R	738 "
Maplewood	I., D. & S. R. R	842 "
Montclair	I., D. & S. R. R	759 "
North Salem	I., D. & S. R. R	888 "
Plainfield	T. H. & I. R. R	742 "
Henry County—		
Kennard	I., B. & W. R. R.	1,057 feet.
Messick	I., B. & W. R. R.	1,030 "
New Castle	I., B. & W. R. R.	1,075 "
New Lisbon	Ft. W., M. & C. R. R.	1,098 "
Spiceland		1,025 "
Howard County—		
Cassville	Panhandle R. R	648 feet.
Kokomo	Panhandle R. R	839 "
Huntington County—		
Huntington	T., W. & W. R. R	734 feet.
"	Court House Square	741 "
Jackson County—		
Chestnut Ridge	J., M. & I. R. R	553 feet.
Crothersville	J., M. & I. R. R	562 "
Rockford	J., M. & I. R. R	585 "
Seymour	J., M. & I. R. R	605 "
"	Crossing O. & M. R. R	608 "

	Authority.	Altitude.
JASPER COUNTY—		
Remington	L., P. & W. R. R	732 feet.
JAY COUNTY—		
Dunkirk	Panhandle R. R	969 feet.
Portland	C., R. & Ft. W. R. R	904 "
Red Key	C., R. & Ft. W. R. R	890 "
JEFFERSON COUNTY—		
Dupont	J., M. & I. R. R	783 feet.
Madison	J., M. & I. R. R	451 "
"	Foot Incline Plane	772 "
North Madison	J., M. & I. R. R	878 "
"	Top of Inclined Plane	876 "
"	Summit Line	880 "
JENNINGS COUNTY—		
Butler's Switch	J., M. & I. R. R	941 feet
North Vernon	J., M. & I. R. R	727 "
Scipio	J., M. & I. R. R	680 "
Vernon	J., M. & I. R. R	686 "
"	Muscatatuck Bridge	669 "
JOHNSON COUNTY—		
Amity	J., M. & I. R. R	693 feet.
Edinburgh	J., M. & I. R. R	694 "
Franklin	J., M. & I. R. R	732 "
"	C., I., St. L. & C. Crossing	736 "
Whiteland	J., M. & I. R. R	805 "
KNOX COUNTY—		
Bruceville	Indianapolis & Vincennes R. R	515 feet
Edwardsport	Indianapolis & Vincennes R. R	460 "
Sanborn	Indianapolis & Vincennes R. R	472 "
Vincennes	E., L. & H. R. R.	463 "
"	C. & V. R. R	417 "
"	Bench mark on Court House	435 "
Westphalia	Indianapolis & Vincennes R. R	456 "
KOSCIUSKO COUNTY—		
Claypool	C., W. & M. R. R	902 feet.
Milford	C., W. & M. R. R	850 "
Silver Lake	C., W. & M. R. R	927 "
Syracuse	B. & O. R. R.	870 "
Warsaw	Crossing L. S. & M. S. R. R	839 "
"	C., W. & M. R. R	824 "
LAGRANGE COUNTY—		
Lagrange	G. R. & Ind. R. R	915 feet
Lima	G. R. & Ind. R. R	882 "
Valentine	G. R. & Ind. R. R	952 "
Wolcottsville	G. R. & Ind. R. R	938 "

	Authority.	Altitude.
LAKE COUNTY—		
Crown Point Station	Pan Handle R. R	714 feet.
Gibson	M. C. R. R	600 "
Hobart	P., Ft. W. & C. R. R	623 "
Lake Station	J. & N. R. R	613 "
Lowell		636
Millers	L. S. & M. S. R. R	625 "
Ross	J. & N. R. R	636 "
Tolleston	M. C. R. R	607 "
Whiting	L. S. & M. S. R. R	606 "
LAPORTE COUNTY—		
Holmesville	L. S. & M. S. R. R	800 feet.
Kingsburg	Peninsula R. R	742 "
Lacrosse	Pan Handle R. R	675 "
Michigan City	M. C. R. R	603 "
Michigan Lake	U. S. Lake Survey	582 "
Otis	L. S. & M. S. R. R	765 "
Rolling Prairie	L. S. & M. S. R. R	821 "
Wanatah	P., Ft. W. & C. R. R	731 "
Westville	L., N. A. & C. R. R	786 "
LAWRENCE COUNTY—		
Bedford	L., N. A & C. R. R.	679 feet.
Mitchell	O. & M. R. R	676 "
MADISON COUNTY—		
Alexandria	L. E. & W. R. R	857 feet.
"	Crossing C., W. & M. R. R	872 "
Anderson	C., C., C. & I. R. R	880 "
"	P., C. & St. L. Crossing	900 "
"	C., C., C. & I. Crossing	894 "
"	C., W. & M. Junction	894 "
Chesterfield	C., C., C. & I. R. R	907 "
Elwood	L. E. & W. R. R.	858 "
Gillman	L. E. & W. R. R.	852 "
Pendleton	C., C., C. & I. R. R	847 "
Summitville	C., W. & M. R. R	1,001 "
MARION COUNTY—		
Acton	C., I., St. L. & C. R. R	792 feet.
Bridgeport	T. H. & I. R. R	748 "
Brightwood	C., C., C. & I. R. R	791 "
Galaudet	C., I., St. L. & C. R. R	852 "
Indianapolis	City datum, City Engineer	676 "
"	Belt R. R. Crossing J., M. & I	722 "
"	Signal Station U. S. Signal Office	753 "
"	Union Depot	721 "
Lawrence	C., C., C. & I. R. R	872 "
Maywood	Indianapolis & Vincennes R. R	695 "
Southport	J., M. & I. R. R	761 "
Valley Mills	Indianapolis & Vincennes R. R	759 "
West Newton	Indianapolis & Vincennes R. R	779 "

	Authority.	Altitude.
Marshall County—		
Plymouth	P., Ft. W. & W. R. R	781 feet.
"	P., K. & P. R. R	769 "
"	Surface Yellow River	760 "
Teegarden	B., P. & C. R. R	794 "
Martin County—		
Loogootee	O. & M. R. R	532 feet.
Shoals	O. & M. R. R	480 "
West Shoals	Center Stone, Cross of Cap on Basement Window W. S. C. H	523 "
Miami County—		
Amboy	Pan Handle R. R	810 feet.
Bunker Hill	Pan Handle R. R	800 "
Chili	Eel River R. R	725 "
Mexico	Eel River R. R	700 "
Peru	W., St. L. & P. R. R	655 "
"	Court House Square	
	W. & E. Canal	657 "
Monroe County—		
Bloomington	L., N. A. & C. R. R	742 feet.
Ellettsville	L., N. A. & C. R. R	682 "
Harrodsburgh	L., N. A. & C. R. R	506 "
Smithville	L., N. A. & C. R. R	717 "
Montgomery County—		
Crawfordsville	L., N. A. & C. R. R	741 feet.
Whitesville	L., N. A. & C. R. R	874 "
Morgan County—		
Brooklyn	Indianapolis & Vincennes R. R	659 feet.
Martinsville	Indianapolis & Vincennes R. R	598 "
Mooresville	Indianapolis & Vincennes R. R	685 "
Paragon	Indianapolis & Vincennes R. R	577 "
Newton County—		
Goodland	T., P. & W. R. R	718 feet.
Kentland	T., P. & W. R. R	681 "
Noble County—		
Albion	B., P. & C. R. R	927 feet.
Avilla	G. R. & Ind. R. R	969 "
"	Summit. B., P. & C. R. R	1,015 "
Brimfield	L. S. & M. S. R. R	945 "
Kendallville	L. S. & M. S. R. R	974 "
Ligonier	L. S. & M. S. R. R	886 "
Rome City	G. R. & Ind. R. R	920 "
Wawaka	L. S. & M. S. R. R	896 "
Orange County—		
Orleans	L., N. A. & C. R. R	633 feet.

OWEN COUNTY—	Authority.	Altitude.
Coal City	T. H. & S. E. R. R	651 feet.
Farmer	Indianapolis & Vincennes R. R	528 "
Freedom	Indianapolis & Vincennes R. R	538 "
Gosport	Indianapolis & Vincennes R. R	595 "
Quincy	L., N. A. & C. R. R.	749 "
Spencer	Indianapolis & Vincennes R. R	557 "

PARKE COUNTY—		
Bloomingdale	I., D. & S. R. R	642 feet.
Guion	I., D. & S. R. R	630 "
Leatherwood	I., D. & S. R. R	572 "
Marshall	I., D. & S. R. R	700 "
Montezuma	I., D. & S. R. R	494 "
Rockville	Gas Well, John T. Campbell, C. E.	688 "

PORTER COUNTY—		
Chesterton	L. S. & M. S. R. R	660 feet.
Furnesville	M. C. R. R	669 "
Hebron	Panhandle R. R	714 "
Kout	Panhandle R. R	688 "
Porter	M. C. R. R	647 "
Valparaiso	P., Ft. W. & C. R. R	738 "
"	Peninsular R. R	801 "
Wheeler	P., Ft. W. & C. R. R	666 "

POSEY COUNTY—		
Mount Vernon	St. L. & S. E. R. R	407 feet.

PULASKI COUNTY—		
Francesvile	L., N. A. & C. R. R	685 feet.
Gundrum	Panhandle R. R	710 "
Star City	Panhandle R. R	706 "
Winamac	Panhandle R. R	713 "

PUTNAM COUNTY—		
Bainbridge	L., N. A. & C. R. R	936 feet.
Barnard	I., D. & S. R. R	902 "
Cloverdale	L., N. A. & C. R. R	782 "
Fillmore	T. H. & I. R. R	844 "
Greencastle	T. H. & I. R. R	834 "
"	Junction L., N. A. & C. R. R	773 "
Hamrick	T. H. & I. R. R.	703 "
Putnamville	L., N. A. & C. R. R	687 "
Raccoon	I., D. & S. R. R	745 "
Reelsville	T. H. & I. R. R	638 "
Roachdale	I., D. & S. R. R	839 "
Russelville	I., D. & S. R. R	828 "

RANDOLPH COUNTY—	Authority.	Altitude.
Bloomingsport	I., B. & W. R. R.	1,225 feet.
Farmland	C., C., C. & I. R. R	1,037 "
Harrisville	C., C., C. & I. R. R	1,101 "
Losantville	I., B. & W. R. R.	1,140 "
Lynn	Crossing I., B. & W. and G. R. & Ind. R. R.,	1,174 "
Parker	C., C., C. & I. R. R.	1,023 "
Ridgeville	Pan Handle R. R	994 "
Union City	C., C., C. & I. R. R	1,108 "
Winchester	C., C., C. & I. R. R	1,089 "
RIPLEY COUNTY—		
Batesville	C., I., St. L. & C. R. R	968 feet.
Milan	O. & M. R. R	985 "
Morris	C., I., St. L. & C. R. R	982 "
Osgood	O. & M. R. R	950 "
Pierceville	O. & M. R. R	1,010 "
Spades	C., I., St. L. & C. R. R	1,013 "
Sunman	C., I., St. L. & C. R. R.	1,015 "
RUSH COUNTY—		
Falmouth	J., M. & I. R. R	1,048 feet.
Homer	J., M. & I. R. R	913 "
Manilla	J., M. & I. R. R	896 "
Rushville	J., M. & I. R. R	964 "
"	Crossing C., H. & I. R. R	972 "
ST. JOSEPH COUNTY—		
Mishawaka	L. S. & M. S. R. R	722 feet.
New Carlisle	L. S. & M. S. R. R	772 "
Osceola	L. S. & M. S. R. R	737 "
South Bend	L. S. & M. S. R. R	725 "
"	Mid. A. L. R. R	679 "
"	Crossing Penn. R. R	733 "
"	St. Joe River, Peninsula R. R	699 "
Terre Coupee	L. S. & M. S. R. R	760 "
SCOTT COUNTY—		
Austin	J., M. & I. R. R	549 feet.
Lexington	O. & M. R. R	626 "
Scottsburgh	J., M. & I. R. R	570 "
Vienna	J., M. & I. R. R	566 "
SHELBY COUNTY—		
Fairland	C., I., St. L. & C. R. R	774 feet.
Flat Rock	J., M. & I. R. R	695 "
Lewis Creek	J., M. & I. R. R	713 "
London	C., I., St. L. & C. R. R	775 "
Morristown	C., H. & I. R. R	842 "
Prescott	C., I., St. L. & C. R. R	792 "
Shelbyville	J., M. & I. R. R	769 "
"	Crossing C., I., St. L. & C. R. R	768 "
Waldron	C., I., St. L. & C. R. R.	819 "

STARKE COUNTY—	*Authority.*	*Altitude.*
English Lake	P., Ft. W. & C. R. R	660 feet.
Hamlet	P., Ft. W. & C. R. R	698 "
North Judson	P., K. & P. R. R	681 "
San Pierre	P., K. & P. R. R.	689 "
STEUBEN COUNTY—		
Angola	Ft. W., J. & S. R. R	1,052 feet.
Freemont	Ft. W., J. & S. R. R	1,055 "
"	Geodetic Station U. S. L. Survey	1,142 "
Pleasant Lake	Ft. W., J. & S. R. R	975 "
SULLIVAN COUNTY—		
Sullivan	E. & T. H. R. R	538 feet.
TIPPECANOE COUNTY—		
Clark's Hill	C., I., St. L. & C. R. R	782 feet.
Dayton	L. E. & W. R. R	648 "
Lafayette	T., W. & W. R. R	595 "
Montmorenci	L. E. & W. R. R	672 "
TIPTON COUNTY—		
Goldsmith	L. E. & W. R. R	903 feet.
Hobbs	L. E. & W. R. R	867 "
Kempton	L. E. & W. R. R	920 "
Tipton	L. E. & W. R. R	868 "
UNION COUNTY—		
Brownsville	C., H. & I. R. R	793 feet.
Liberty	C., H. & I. R. R	979 "
VANDERBURGH COUNTY—		
Evansville	L., E., E. & S. W. R. R	378 feet.
"	Low Water, Ohio River	326 "
VERMILLION COUNTY—		
Clinton	E., T. H. & C. R. R	494 feet.
Dana	I., D. & S. R. R	643 "
Eugene	E., T. H. & C. R. R	507 "
Gessie	E., T. H. & C. R. R	616 "
Hillsdale	I., D. & S. R. R	452 "
Newport	E., T. H. & C. R. R	494 "
Perrysville	E., T. H. & C. R. R	582 "
Summit Grove	E., T. H. & C. R. R	520 "
VIGO COUNTY—		
Atherton	E., T. H. & C. R. R	522 feet.
Riley	T. H. & S. E. R. R	569 "
Seelyville	T. H. & I. R. R	585 "
Terre Haute	E., T. H. & C. R. R	492 "
	7th Street Crossing T. H. & I. R. R	496 "

Place	Authority.	Altitude.
WABASH COUNTY—		
La Fontaine	C., W. & M. R. R	894 feet.
La Gro	T., W. & W. R. R	698 "
Laketon	Eel River R. R	762 "
Liberty Mills	Eel River R. R	773 "
North Manchester	Eel River R. R	775 "
Roann	Eel River R. R	750 "
Urbana	C., W. & M. R. R	815 "
Wabash	W., St. L. & P. R. R	735 "
"	C. H. Sq., W. & E. Canal	730 "
"	W., St. L. & P. Crossing over C., W. & M. R. R	742 "
WARREN COUNTY—		
Marshfield	T., W. & W. R. R	721 feet.
West Lebanon	T., W. & W. R. R	720 "
Williamsport	T., W. & W. R. R	619 "
WARRICK COUNTY—		
Boonville	L., E., E. & S. W. R. R	391 feet.
Chandler	L., E., E. & S. W. R. R	406 "
De Forest	L., E., E. & S. W. R. R	406 "
WASHINGTON COUNTY—		
Harristown	L., N. A. & C. R. R	872 feet.
Salem	L., N. A. & C. R. R	714 "
WAYNE COUNTY—		
Beesons	Ft. W., M. & C. R. R.	875 feet.
Cambridge City	J., M. & I. R. R	941 "
Green's Fork	I., B. & W. R. R	1,120 "
Richmond	C., R. & Ft. W. R. R.	969 "
"	Low Water, Whitewater River	885 "
WELLS COUNTY—		
Bluffton	Ft. W., M. & C. R. R	837 feet.
Keystone	Ft. W., M. & C. R. R	871 "
Ossian	Ft. W., M. & C. R. R	831 "
WHITE COUNTY—		
Chalmers	L., N. A. & C. R. R	707 feet.
Idaville	T., P. & W. R. R.	712 "
Monticello	T., P. & W. R. R.	672 "
Reynolds	T., P. & W. R. R.	692 "
WHITLEY COUNTY—		
Cherubusco	Eel River R. R	725 feet.
Collamer	Eel River R. R	795 "
Collins	Eel River R. R	870 "
Columbia City	P., Ft. W. & C. R. R	836 "
South Whitley	Eel River R. R	808 "

ECONOMIC USE OF NATURAL GAS.

Natural gas is used for two purposes, heating and lighting. It produces intense heat, and may be used in the reduction of the most refractory metals; in the manufacture of brick, tile, porcelain and glass; for producing steam, and for all domestic purposes. It is comparatively free from sulphuric and other deleterious acids, which makes it particularly valuable in foundries, machine shops, and in all manufactories which manufacture metal goods. It is greatly superior to all other fuels used in the manufacture of glass.

It is most important in building up the manufacturing interests of any locality producing it. Its appreciation as a fuel by manufacturers may be better understood by a review of the manufacturing industries located within the gas area of Indiana within the past year. These embrace manufactories engaged in the manufacture of straw board, straw paper, wood pulp and wood paper, steel works, foundries, nail mills, bar and bolt works, and bell foundries; plate glass, window glass, fruit cans, and bottle factories; crayon factories, fruit-canning factories, excelsior mills, saw-mills and flouring mills; brick and tile factories, and many other industries, in which several million dollars are invested and hundreds of hands employed.

At Anderson, Madison County, are located a number of large concerns, which have changed the city from a quiet commercial place to a bustling manufacturing center. The following named manufactories are already located at Anderson, and capitalists are almost daily visiting that place, as well as all the other more important points, with a view of locating manufacturing enterprises.

UNION STRAWBOARD WORKS.

Incorporated.
Capital invested, $200,000.
Number of employes, 150.
Wages of unskilled laborers, 75 cents to $1.25 per day.
Wages of skilled laborers, $1.50 to $2.50 per day.
Capacity of the works, 30 tons per day.
Price of product to consumers, 42½ cents per ton.
Principal raw materials used, straw and lime.
Raw material all obtained in Indiana.

Horse-power of engines, 800.

Horse-power of boilers, 1,200.

The principal uses of the product are in the manufacture of paper boxes, car wheels, house lining, egg cases, berry baskets, carpet lining, etc.

ANDERSON BOLT WORKS.

Incorporated in New York.

Cost of plant and working capital, $250,000.

Number of employes, 100.

Wages of unskilled laborers, $1.00 per day.

Wages of skilled laborers, $2.50 per day.

Manufacture bolts, nuts, leg screws, etc.

Daily capacity, 15,000 pounds.

The raw material is all procured from the Mahoning Valley, Ohio.

Power of boiler, 80-horse.

Power of engine, 80-horse.

ANDERSON KNIFE AND BAR WORKS.

Silas E. Famen, Superintendent.

Manufacture machine knives of all kinds, etc.

Cost of plant and working capital, $50,000.

Value of annual product, $100,000.

Number of employes, 50.

Wages of unskilled laborers, $1.25 to $1.50 per day.

Wages of skilled laborers, $2.00 to $3.00 per day.

Power of engine, 150-horse.

Their grindstones are procured from Marietta and Cleveland, Ohio. Their high grade steel is obtained from England and their low grade steel from Pittsburg.

BUTLER GLASS COMPANY, OF ANDERSON, INDIANA.

Incorporated.

Cost of plant and working capital, $33,000.

Number of men employed, 30.

Number of boys employed, 40.

Wages of skilled men, $4.00 to $6.00 per day.

Wages of unskilled men, $1.75 per day.

Wages of boys, 50 cents per day.

Value of annual product, $60,000.

Manufacture flint bottles.

Their sand is procured at Pendleton, Indiana, their ground limestone from Cleveland, Ohio, and their soda ash from England.

THE AMERICAN WIRE NAIL COMPANY, OF COVINGTON, KENTUCKY.

Incorporated.
Cost of plant and working capital, $500,000.
Manufacture steel rods, steel wire and wire nails.
Capacity of steel rod mill, 100 tons per day.
Capacity of steel wire mill, 75 tons per day.
Capacity of nail mill, 1,500 kegs per day.
Number of hands employed, 300.
Wages of skilled men, $3.00 to $5.00 per day.
Wages of unskilled men, $1.50 per day.
Power of engine, 2,000-horse.
Raw material, steel billets, imported from England and bought in Pittsburg.

SEFTON MANUFACTURING COMPANY.

Manufacture paper pails, etc.
Will employ between 200 to 300 hands.
This concern is located, but has not yet begun work.

JONES & CLEMENT'S BRICK YARD.

Manufacture machine pressed brick.
Capital invested, $25,000.
Number of employes, 30.
Wages of employes, $1.50 per day.
Daily product, 25,000 brick.
Steam power used, 40-horse.
The bricks are dried with hot air, burned with natural gas, and the work is continued the year round.
The brick-sand is obtained from Sandusky, Ohio.

MANUFACTORIES AT DUNKIRK.

Dunkirk is a small town in the southwestern part of Jay County. The Chicago, St. Louis & Pittsburg Railroad passes through it. In 1880 the population was 662. The following important manufacturing establishments have been located there and are in active operation:

THE DUNKIRK WINDOW GLASS COMPANY.

J. F. Wilcox, President.
C. P. Cole, Secretary and Treasury.
John Ames, Superintendent.
Incorporated,

Capital stock, $25,000.

Cost of plant and working capital, $40,000.

Number of furnaces, 2.

Number of pots, 12.

Number of employes, 65.

Average weekly pay-roll, $900.

Engine power, 15-horse.

The sand used is obtained from Millington, Illinois.

The salt cake and soda ash used are obtained from England.

The daily product of the factory is 225 boxes of window glass of 50 feet each.

THE DUNKIRK EXCELSIOR WORKS.

Charles A. Maish & Co., Cincinnati, proprietors.

Capital invested, $9,000.

Number of employes, 10.

Weekly pay-roll, $80.

Daily product, 5 tons.

Boiler power, 50-horse.

Engine power, 45-horse.

The raw material is all procured in Indiana.

MANUFACTORIES AT EATON.

Eaton is the pioneer of natural gas towns in Indiana. The first natural gas in the present broad gas field of this State was found here. An account of the pioneer work done at Eaton is given in the fifteenth annual report of the Department of Geology and Natural History.

One excelsior manufactory is located here. Ames & Carter, proprietors.

Number of employes, 14.

Wages of employes, $1.25 to $1.50 per day.

Capacity of works, 6 to 8 tons per day.

Power of engine, 60-horse.

The raw material is all obtained in the vicinity of Eaton.

MANUFACTORIES AT ELWOOD.

At Elwood, a thriving town in the northwestern part of Madison County, on the Lake Erie & Western Railroad, are located the following factories:

LEESON & MARSH EXCELSIOR COMPANY.

Capital invested, $4,000.

Number of employes, 12.

Wages of employes, $1.25 to $1.50 per day.

ELWOOD PLANING MILL COMPANY.

Capital invested, $8,000.
Employes, 12.
Wages of employes, $1.25 to $1.50 per day.
Raw material for both concerns is all obtained in Indiana.

MANUFACTORIES AT FAIRMONT

FLOURING MILL.

Capital employed, $8,000.
Capacity, 100 barrels per day.
Number of employes, 7.
Average wages of employes, $1.50 per day.
Raw material obtained in Indiana.

HOOP MANUFACTORY.

Capital invested, $6,500.
Number of employes, 20.
Average wages of employes, $1.25 per day.
Product amounts to $1,200 per month.
Raw material obtained in the vicinity of the town

EXCELSIOR MANUFACTURING COMPANY.

Capital invested, $2,500.
Number of employes, 15.
Average wages of employes, $1.25 per day.
Value of product, $1,500 per month.
Raw material all obtained in the vicinity of Fairmont

ROLLER MILL REDUCTION MACHINERY MANUFACTURING COMPANY.

Capital invested, $20,000.
Will employ from 25 to 50 hands.

SAW AND PLANING MILL.*

Capital invested, $10,000.
Number of employes, 30.
Wages of employes, $1.25 to $1.50 per day.
Raw material obtained in Indiana.

* Has been destroyed by fire.

MANUFACTORIES AT HARTFORD CITY.

HARTFORD PULP COMPANY.

A. Reynalds, President.
ncorporated.
Capital, $30,000.
Manufacture wood pulp.
Number of employes, 20.
Weekly pay-roll, $220.
Capacity of works, 4 tons, dry, per day.
Power of engine, 550-horse.
Power of boiler, 700-horse.
Raw material all obtained in Indiana.

HARTFORD CITY EXCELSIOR WORKS.

Capital invested, $3,000.
Number of employes, 10.
Average wages of employes, $1.25 per day.
Power of engine, 16-horse.
Will soon put in a 60-horse power engine.

CHICAGO STEEL ROLLING MILL COMPANY.

Incorporated.
Capital stock, $200,000.
Number of employes, 100.
Not yet in operation, but guaranteed to run 300 days in the year.

MANUFACTORIES AT KOKOMO.

KOKOMO STRAW BOARD COMPANY.

Incorporated.
Capital stock, $200,000.
Number of employes, 80.
Wages of unskilled laborers, $1.50 per day.
Wages of skilled workmen, $2.25 per day.
Number of boilers, 8.
Total boiler capacity, 1,100-horse power.
One engine of 250-horse power.
One engine of 80-horse power.
One engine of 60-horse power.
Total horse-power, 390.

Manufacture the finest quality of straw-board, or what is commonly termed "paste-board."

Lime obtained from Marion, Ohio.

Straw obtained in Indiana.

Capacity, 18 tons per day.

THE NEWMAN PAPER COMPANY.

Manufacture of wood pulp.

Incorporated.

Capital stock, $50,000.

Number of employes, 20.

Average wages of unskilled hands, $1.25 per day.

Average wages of skilled men, $2.00.

Capacity of works, 15 tons per day.

Value of product, $40 to $50 per ton.

Engine power, 150-horse.

Boiler power, 240-horse.

Raw material obtained from the Kokomo wood pulp mill.

ROCKFORD BIT WORKS.

Incorporated.

Capital stock, $40,000.

Manufacture augurs and bits of all kinds.

Number of employes, 75.

Wages of skilled workmen, $2.25 per day.

Wages of unskilled workmen, $1.00 per day.

Raw material all of domestic production.

Capacity of works, 1,000 bits per day.

Boiler power, 65-horse.

Engine power, 50-horse.

HOWARD GLASS COMPANY.

Capital invested, $6,500.

Tank factory, with 10-pot capacity.

Employes, 40.

Wages of skilled men, $4.00 to $6.00 per day.

Wages of unskilled men, $1.25 per day.

ROCK ISLAND KNIFE AND SHEAR WORKS.

Incorporated.
Capital, $33,000.
Number of employes, 30.
Wages of skilled workmen, $3.00 per day.
Wages of unskilled laborers, $1.00 per day.
Capacity of works, thirty dozen pairs per day.
American iron and steel used exclusively.
Boiler, 30-horse power capacity.
Engine, 25-horse power capacity.

OPALESCENT GLASS WORKS.

Capital invested, $10,000.
Number of pots, 7.
Number of employes, 50.
Wages of skilled men, $3.00 to $5.00 per day.
Wages of unskilled men, $1.50 per day.
Manufacture colored and ornamental glassware.
Sand obtained from Millington, Illinois.
Soda, ash and potash, imported.

DIAMOND PLATE GLASS WORKS.

Incorporated.
Capital stock, $500,000.
Manufacture plate glass.
Number of employes, 400 to 500.
Average wages of skilled workmen, $4.00 per day.
Average wages of unskilled workmen, $1.50 per day.
Number of pots, 40.
Capacity of pots, 100 to 125 square feet of glass each.
Daily capacity of works, 4,500 square feet.
One engine, of 600-horse power.
Fifteen engines, of 60-horse power each.
Glass sand obtained from Millington, Illinois
Grinding sand obtained from local deposits.
Lime obtained, probably, from Depauw, at New Albany, Indiana.

This institution is not yet in operation, but is rapidly approaching completion.

KOKOMO GLASS WORKS.

Manufacture window glass.
Incorporated.
Capital stock, $50,000.
Number of employes, 65.
Average wages of employes, $100 per month.
One 10-pot furnace.
Capacity of works, 4,000 50-feet boxes of glass per month.
Sand obtained from Millington, Illinois.
Salt cake imported from England.
Lime obtained from Depauw, at New Albany, Indiana.
This concern was moved to Kokomo from Ithaca, New York.

KOKOMO MACHINE BRICK AND TILE MANUFACTORY.

Capital invested, $20,000.
Number of hands employed, 35.
Average wages of hands, $1.40 per day.
Value of annual product, $25,000.
Power of engine, 40-horse.
Clay obtained at Kokomo.

GERMAN & TEEGARDIN.

Manufacture threshers and grain weighers.
Capital invested, $12,000.
Number of employes, 12.
Average wages of employes, $2.00 per day.
Power of engine, 40-horse.
The iron used is obtained from Indianapolis.
The wood used is obtained in Indiana.

CHARLES & MARTZ, CANNING MANUFACTORY.

Cost of plant, $20,000.
Working capital, $20,000.
Number of employes, 400.
Wages of employes, $3.00 to $6.00 per week.
Boiler power, 160-horse.
Engine power, 120-horse.
Number of regular hands, 25.
Wages of regular hands, $900 per week.

Fruits and vegetables used in the works all produced in the vicinity of Kokomo.

Besides the above, the following named firms have located and will soon be in operation:

Kokomo Boiler Manufactory.

Kokomo Pulp Company.

Kokomo Planing Mill.

MANUFACTORIES AT MARION.

MARION PULP CO.

Incorporated.

Capital stock, $25,000.

Cost of plant and working capital, $60,000.

Number of employes, 100.

Wages of skilled laborers, $2.00 per day.

Wages of unskilled laborers, $1.35 per day.

Capacity of works, 40 tons per day.

It is sold at $10.00 per ton.

Five boilers of 200-horse power each.

Two engines of 500-horse power each.

The product is used for book and newspapers. The pulp is made o buckeye, cottonwood, spruce and quaking ash, all of which grow in Indiana. Works run day and night.

MARION BRICK WORKS.

Incorporated.

Capital stock, $50,000.

Manufacture machine pressed bricks.

Cost of plant, $42,000.

Working capital, $8,000.

Number of employes, 60.

Annual capacity, 12,000,000 bricks.

Average wages of employes, $1.62½ per day.

Twenty per cent. of the employes are boys.

Wages vary from 60c. to $4.00 per day.

Value of annual output, $120,000.

MARION WINDOW GLASS WORKS.

Incorporated.

Capital stock, $30,000.

Cost of plant, $26,000.

Working capital, $10,000.

Manufacture window glass.
Number of pots, 10.
Capacity of works, 800 boxes of glass of 50 feet each per week.
Number of employes, 75.
Average wages of skilled laborers, $5.00 per day.
Average wages of unskilled laborers, $2.00 per day.
Sand obtained from Illinois and Michigan, soda ash from England.

MARION FLINT GLASS COMPANY.

Incorporated.
Capital stock, paid up, $25,000.
Cost of plant, $20,000.
Working capital, $13,000.
Number of men employed, 72.
Number of boys employed, 44.
Wages of blowers, $5.00 per day.
Wages of packers, $2.50 to $3.00 per day.
Wages of unskilled men, $2.00 per day.
Wages of boys, 50c. per day.
Average age of boys employed, 13 years.
Value of monthly output, $10,000.
Number of pots, 12.
Sand is obtained from Chicago; soda ash all comes from England; lime from Indiana.

SWEAZY & JOHNSON.

Manufacture butchers' skewers.
Cost of plant, $25,000.
Working capital employed, $10,000.
Number of employes, 62.
Number of skilled laborers, 15.
Number of unskilled men, 32.
Number of girls, 15.
Wages of skilled men, $1.50 per day.
Wages of unskilled men and girls, $1.00 per day.
Value of annual product, $50,000.
Power furnished by two 14x20 (200-horse power) engines.
Raw material all obtained in Indiana.

PARMENTER CRAYON COMPANY.

Cost of plant, $7,000.
Number of men employed, 5.
Number of boys employed, 7.

Daily average wages of men, \$2.00.

Daily average wages of boys, 75 cents.

Engine power, 10-horse.

Raw material, clay and plaster, imported from Germany and Nova Scotia.

BARTON BELL COMPANY.

Incorporated.

Capital stock, \$30,000.

Number of employes, 40.

Wages of skilled men, \$2.00 per day.

Wages of unskilled men, \$1.20 per day.

Value of annual product, \$40,000.

Power of engine, 25-horse.

Manufacture small bells. Copper and tin obtained from New York and Baltimore.

STUDEBAKER & VON BEHREN MANUFACTURING COMPANY.

Incorporated.

Capital stock, \$15,000.

Manufacture hardwood wagon stuff.

Product per month, 600,000 feet.

Number of employes, 70.

Seven skilled workmen earn each \$2.50 per day.

Sixty-three unskilled workmen, each earns \$1.35 per day.

Engine power; 140-horse.

Raw material all obtained in Indiana.

AMERICAN SOAP COMPANY.

Incorporated.

Capital, \$6,000.

Cost of plant, \$6,000.

Working capital, \$10,000.

SWEET & CLARK MANUFACTURING COMPANY, OF TROY, NEW YORK.

Cost of plant, \$60,000.

Working capital, \$150,000.

Will employ about 600 men.

Will manufacture malleable iron goods.

These works are not yet in operation, but they are rapidly approaching completion.

CROSBY PAPER COMPANY.

Incorporated.
Capital stock, ———.
Number of employes, 36.
Men employed, 30.
Women employed, 6.
Average wages of men, \$1.66$\frac{2}{3}$ per day.
Average wages of women, 83$\frac{1}{3}$ cents per day.
Number of rotarys, 2.
One 40-horse power engine, one 160-horse power engine.
One 175-horse power boiler.

M'CULLOUGH & WILLSON, MARION FRUIT JAR AND BOTTLE COMPANY.

Capital invested, \$40,000.
Men employed, 40.
Boys employed, 60.
Number of pots, 8.
Product, 75 gross of jars per day.

STEWART, ESTEP & CO.

Manufacture window glass.
Cost of plant and working capital, \$50,000.
Number of employes, 125.
Wages of skilled laborers, \$5.00 to \$6.00 per day.
Wages of unskilled men, \$1.75 to \$2.00 per day.
Number of pots, 26.
Daily capacity of works, 400 fifty-foot boxes of glass.
Sand obtained from Garden City, Illinois, 70 miles west of Chicago.
Use salt cake and soda ash; part imported and part domestic.

WISE & NELSON.

Manufacture lumber, patent coiled hoops and chair stuff.
Cost of plant and working capital, \$20,000.
Number of employes, 56.
Number of men employed, 39.
Number of boys employed, 17.
Average wages of skilled men, \$2.00 per day.
Average wages of unskilled men, \$1.25 per day
Average wages of boys, 75 cents per day.
Lumber manufactured, per day, 8,000 feet.
Hoops manufactured, per day, 32,000.

Chair stuff, made of beech, oak, sugar and hickory, manufactured, per week, 2 car loads.

Engine power, 100 horse.

Raw material all obtained in Indiana.

MARION EXCELSIOR WORKS.

George S. Landes, Manager.

Capital invested, $8,000.

Number of employes, 15.

Average wages of employes, $1.25 per day.

Daily product in 10 hours, 65 bales of 115 pounds each.

Daily product, night and day work, 130 bales.

Power of engine, 40-horse.

Raw material all obtained in Indiana.

Excelsior is used by mattress and carriage makers, for packing, etc.

MARION STOVE COMPANY.

Manufacture stoves and hollow ware.

Number of employes, 50.

Averages of employes, $10 per week.

Product amounts to $50,000 annually.

Iron obtained from Lake Superior and Southern Ohio.

This concern was formerly the Sidney Manufacturing Company, of Sidney, Ohio.

MANUFACTORIES AT MUNCIE.

MUNCIE PULP COMPANY.

Incorporated.

Capital stock, $150,000.

Manufacture wood pulp.

Number of employes, 80.

Capacity of works, 20 tons per day.

Engine power, 400-horse.

Boiler power, 800-horse.

Raw material all obtained in Indiana.

MUNCIE COMBINATION MANUFACTURING COMPANY.

Incorporated.

Capital stock, $25,000.

Number of employes, 25.

Average daily wages of hands, $1.50.

Power of engine, 25-horse.

Raw material all obtained in Indiana.

BALL GLASS WORKS.

Incorporated.
Capital stock, $40,000.
Manufacture fruit jars, green and amber bottles.
Number of furnaces, 2.
Number of pots, 9.
Number of employes, 125.
Weekly pay-roll, $1,200.
Value of daily product, $700.
Power of engine, 12-horse.
Sand obtained from Millington, Ill.
Lime obtained from Fostoria, Ohio.
Soda ash obtained from England.

HEMINGRAY GLASS COMPANY.

Incorporated.
Capital stock, $250,000.
Number of employes, 100.
Average weekly pay-roll, $800.
Number of furnaces, 1.
Number of pots, 14.
Sand obtained from Millington, Ill.
Use domestic soda ash.
Manufacture all kinds of bottles.
This concern also has large glass works at Covington, Ky.

C. H. OVER, WINDOW GLASS WORKS.

Capital invested, $45,000.
Number of employes, 84.
Average weekly pay-roll, $1,400.
Number of furnaces, 2.
Number of pots, 16.
Sand obtained from Millington, Ill.
Lime obtained from Kelly Island.
Use foreign and imported salt cake and soda ash.
Weekly capacity, 1,400 boxes of glass.

MUNCIE NAIL COMPANY.

Incorporated.
Capital stock, $200,000.
Manufacture steel and iron nails, and all kind of cut nails.
Number of employes, 200.
Monthly pay-roll, $10,000.

Daily capacity, 500 kegs of nails.
One engine of 300-horse power.
One engine of 150-horse power.
Three engines of 50-horse power each.
Use American iron, principally from Alabama.
Steel used comes principally from Mingo Junction, Ohio.
This concern was formerly located at Greencastle, Ind., and known as the Greencastle Nail Company.

MARING, HART & CO.

Manufacture window glass.
Cost of plant, $30,000.
Working capital, $70,000.
Total invested, $100,000.
Number of employes, 120.
Average wages of skilled men, $4.00 per day.
Wages of unskilled men, $9.00 to $12.60 per week.
Number of furnaces, 2.
Number of pots, 20.
Capacity of works, 7,680 fifty feet boxes of glass per month.
Sand obtained from Millington, Ill.
Soda ash obtained from England.
Use domestic salt cake.

Other manufactories for which no statistics were obtained:
Muncie Veneering Works.
Washing Machine Manufactory.
Muncie Rubber Mill.

MANUFACTORIES AT NOBLESVILLE.

NOBLESVILLE FOUNDRY AND MACHINE WORKS.

Incorporated.
Capital stock, $35,000.
Do general foundry and machine work.
Number of employes, 40.
Daily wages of skilled men, $2.00.
Daily wages of unskilled men, $1.25.
Value of annual product, $20,000.
Engine power, 50-horse.
Boiler power, 40-horse.
Use Ohio iron and Pittsburgh American steel.

NOBLESVILLE NOVELTY WORKS.

Manufacture hardware novelties.
Capital invested, $26,000.
Number of employes, 50.
Average wages of employes, $2.00 per day.
Boiler and engine power, 35-horse.

NOBLESVILLE MANUFACTURING COMPANY.

Manufacture chemical straw and wood paper.
Incorporated.
Capital stock, $150,000.
Employes, 75.
Capacity of works, 15 to 20 tons per day.
Boiler power, 800-horse.
One engine of 350-horse power.
Two engines of 75-horse power each.
Raw material consisting of buckeye, white beech, "quaking ash," wood and straw is procured in Indiana.

NORDYKE & MORMON.

Flouring mill.

MANUFACTORIES AT PENDLETON.

PENDLETON WINDOW GLASS WORKS.

Incorporated.
Capital stock, $50,000.
Number of employes, 75.
Average wages of skilled employes, $5.00 per day.
Average wages of unskilled men, $1.50 per day.
Number of pots, 12.

MANUFACTORIES AT PORTLAND.

H. C. VAUGHT & SONS.

Manufacture furniture.
Capital invested, $10,000.
Number of employes, 15.
Average daily wages, $1.30.
Power of engine, 35-horse.
Raw material all obtained in Indiana.

PORTLAND HANDLE MANUFACTURING COMPANY.

Number of employes, 30.
Average wages of hands, $1.50 per day.
Capacity of works, 3,000 handles per day.
One engine of 35-horse power.
One engine of 30-horse power.

The foregoing extensive list of manufacturing concerns embraces those only that have been located in Indiana since the discovery of natural gas. The list is not complete, for the reason that since the facts presented above were obtained, there have been other enterprises located at a number of points.

Many of the concerns named in the list are those that have been moved from localities where no natural gas can be procured, others are from localities where gas is furnished in sufficient quantities, but the prices are so high that from an economical stand-point, natural gas possesses no advantage over coal or other fuel. For instance, at Pittsburg the price of gas to glass manufacturers is $50 to $60 per pot. In Indiana, so far, gas is furnished free to glass manufacturers, and other concerns, also. Glass works are run about ten months in the year. A 26-pot factory, therefore, at Pittsburg is required to pay $13,000 to $15,600 per year for fuel, all of which is saved in Indiana. Even if gas is not furnished absolutely free, as an inducement for a manufacturer to locate in the Indiana field, he can secure it comparatively without cost by boring his own well upon his own land, and immediately adjoining his works, where the piping will not add materially to the price of a well. The cost of drilling a well in the Indiana gas field at this time, is from $850 to $1,000.

A fair proportion of the manufactories located in the Indiana gas area are enterprises that are wholly new. They have all undoubtedly been drawn to this region on account of the cheapness and convenience of the fuel. Without natural gas it is not likely that any new factories would have been located throughout all this wide extent of territory except such lumber and grist mills as were required to supply the local demand for their product.

During the brief period of time that has elapsed since gas was discovered, eastern Indiana has become fairly a manufacturing region, giving employment to thousands of persons, directly and indirectly, and producing annually a vast and varied amount of manufactured goods. The prospects for the immediate future are flattering in the extreme.

A summary of the manufacturing establishments located in the gas area of Indiana is given below:

GLASS MANUFACTORIES.

Number of window glass manufactories	7
Capital invested in window glass factories	$327,500
Number of pots in window glass factories	104
Number of employes in window glass factories	579
Total number of plate glass manufactories	1
Capital invested in plate glass works	$500,000
Number of employes in plate glass works	500
Number of pots in plate glass works	40
Number of fruit jar, bottle and opalescent glass factories	6
Capital invested in fruit jar, bottle and opalescent glass factories	$206,000
Number of pots in same	62
Number of employes in same	551
Total number of glass factories	14
Total capital invested in glass factories	$1,033,500
Total number of employes in glass factories	1,630
Total number of pots in glass factories	206

IRON MANUFACTORIES.

Number of nail mills	2
Capital invested in nail mills	$700,000
Number of employes	750
Daily capacity of nail mills, kegs	2,000
Number of foundries	3
Capital invested in foundries	$75,000
Number of employes in foundries	102
Value of annual product	$85,000
Knife and bar works	1
Capital invested in bar works	$50,000
Hands employed in bar works	50
Value of annual product	$100,000
Bolt works	1
Capital invested in bolt works	$250,000
Hands employed in bolt works	100
Amount of daily product, pounds	15,000

Rolling mills	1
Capital invested	$200,000
Number of employes	100
Estimated value of product annually	$500,000
Knife and shear works	1
Capital invested	$33,000
Hands employed	30
Amount of daily product, dozens	15
Bit works	1
Capital invested	$40,000
Number of employes	75
Daily product, bits	1,000
Novelty hardware works	1
Capital invested	$26,000
Number of hands employed	50
Estimated value of annual product	$100,000
Malleable iron works	1
Capital invested	$210,000
Number of employes	600
Estimated value of product annually	$1,200,000
Total number of iron manufactories	12
Total amount invested	$1,634,000
Total number of employes	1,907
Estimated value of product annually	$4,200,000

BELL FOUNDRIES.

Total number of factories	1
Capital invested	$30,000
Number of employes	40
Value of annual product	$40,000

STRAW BOARD AND PAPER MANUFACTORIES.

Total number of factories	4
Total capital invested	$650,000
Total number of employes	341
Daily product, tons	78
Value of annual product	$1,000,000

WOOD PULP WORKS.

Total number of factories	4
Total capital invested	$290,000
Total number of employes	213
Daily product, tons	75
Value of annual product	$300,000

BRICK AND TILE MANUFACTORIES.

Total number of factories	9
Capital invested	$295,000
Number of employes	245
Annual product	*41,750,000

WOOD WORKING MANUFACTORIES.

These include wagon factories, skewer factories, hoop factories, handle factories, planing and saw mills, etc.

Total number of factories	13
Total capital invested	$159,500
Total number of employes	394
Value of annual product	$482,000

EXCELSIOR MANUFACTORIES.

Total number of factories	6
Total amount invested	$38,500
Total number of employes	75
Total daily product, tons	45

FLOURING MILLS.

Total number of mills	4
Total amount invested	$66,000
Total number of employes	162
Total daily product, barrels	350

MISCELLANEOUS MANUFACTORIES.

Total number of factories	12
Total capital invested	$266,000
Total number employes	727
Amount of annual product	$500,000

The miscellaneous factories include crayon factories, fruit canning establishments and other industries.

*Brick. The amount of tile not ascertained.

The facts given above will not be complete of course when this report goes to press because new concerns are being located almost daily. The amount of capital drawn to the Indiana gas field on acconnt of the cheapness and superiority of the fuel, and other advantages, is not less than $300,000 per moth.

RECAPITULATION.

Total number of manufactories	79
Total capital invested	$4,462,500
Total number of hands employed	5,734

Aside from its great value for manufacturing purposes, natural gas is superior in every respect for domestic purposes. It saves the expense of coal and wood sheds, the inconvenience of handling the fuel, of kindling fires and removing the ashes and other waste or refuse matter from the stove or grate. Its combustion is not accompanied with volumes of smoke nor accumulations of soot.

Almost every town or hamlet, if not all, throughout the gas area, now has one or more gas wells. Pipes have been laid and gas has wholly supplanted wood and coal for fuel. All shops, stores and other business houses have adopted the use of the new fuel, and in nearly every instance the residences and business houses are lighted as well as heated with natural gas. In addition to this many of the farmers throughout the gas area have piped gas to their residences, or have drilled wells of their own, and are now using gas for heat and light.

The outlay of money by the various corporations, local organizations and individuals, in boring for gas and laying mains throughout the gas area, is enormous, amounting to several millions of dollars.

Among the facts presented above, concerning the manufactories in the State, the point from which the raw material used in the various factories is given. In many instances it will be noticed that all the raw material is produced in this State. In some cases this material is found in the immediate vicinity of the factory, and in other cases it is obtained from other parts of the State. The introduction of new factories has thus afforded a market for quite a number of the State's products that were hitherto unmarketable on account of the distance they had to be transported.

In many instances a large part of the raw material used in some factories is brought from neighboring States that might just as well be furnished by our own people at just as reasonable prices as are paid for it elsewhere. It requires only a little energy, sometimes, to place an article upon the market that has all along been regarded as of little value, but, when once introduced, will be the source of a steady and satisfactory income. The clays and sands of many localities of this State are well adapted to use in many different ways, and our woods—those that have been assumed to have little value—are likely to prove the source of great profit.

THE STRUCTURE, CLASSIFICATION AND ARRANGEMENT OF AMERICAN PALÆOZOIC CRINOIDS INTO FAMILIES.

BY S. A. MILLER.

There have been described from North American Palæozoic rocks 1,100 species of crinoids, which are referred to about 110 genera. The arrangement of these genera into families, based upon uniform and consistent rules, is the object of this article.

When I published my work on North American Geology and Palæontology I proposed a few new family names, but as my object then was to present the state of the science as it existed, and not to write an original treatise on any one branch, I generally followed the classification of others, and as they were not in accord as to family characters, the families as there given are not of equal value. The new family names which I proposed were not defined and hence were used only provisionally, and because I could not refer the genera to families that had been limited and defined. Indeed, I did not have the time to properly classify the genera into families nor access to the fossils for the purpose of verifying such classification if I had taken the time from other duties. Since that work was done I have had an opportunity to inspect a large lot of crinoids from Mr. Gurley's collection, in addition to those in my own cabinet, and to review the various systems of classification in use in this country, and now propose to present my views of family classification.

I would desire to state, in the first place, that, in many instances, I do not agree with the views of Wachsmuth and Springer as to family characters and the classificatory value of the structural parts of crinoids, and while I may refer the same genera to some families that they do, yet the reasons therefor are not the same. I believe families should be established upon the structure of the calyx, and for this purpose the number of the basal plates is first in importance; second in importance is the presence or absence of subradials; third, the presence or absence of regular interradials, and, after this, comes the structure of the azygous side and other parts. For the purpose of showing how radically we differ, I will quote a few sentences from their work on the Palæocrinoidea:

"A subdivision according to the number of basal plates may facilitate elementary studies, but it is certainly not a natural classification."

"In the first part of this work we have discussed somewhat fully the relations of the underbasals which we took to be the product of growth in geological time, introduced gradually by interpolation between the basals. It is very remarkable that although the introduction of underbasals dates back to the Lower Silurian, as a rule, the genera in which those plates are found differ at no time materially from those in which they are wanting."

"We have, in the introduction to this work, page 17, dwelt at some length upon the basals or first ring of plates below the radials, and believe we have shown that the basal disk, whether composed of one, two, three, four or five pieces, can almost invariably be reduced to five elementary pieces, and that all deviations from this number have been produced by anchylosis of two or more of the original segments. This of itself is a strong argument against a classification based upon the number of these plates."

"It is apparent from these facts that neither the existence of underbasals, nor the modifications which took place in the basal disk, had any such corresponding effect upon the general structure of the crinoids as to entitle them to be considered characters of family importance, though in distinguishing subordinate groups they may possess some value. The radial and interradial plates are elements of far greater value."

They maintain that "a character in forms of the same geological age may be generic in one case and only specific in another," that "arm structure is of generic importance as a rule, but scarcely of specific value in exceptional cases." To neither of which views do I subscribe. So many of the opinions presented in the first part of the Palæocrinoidea are withdrawn or declared to be erroneous in the third part, and in subsequent papers, that one can not be certain, when quoting their expressions, that he is really giving their latest views, unless he is a constant student of their productions. For instance, the groove in the arms of the crinoids was almost universally covered with small plates, whether the arms had pinnules or not, but in the first part of their work they say:

"It is here important to note that in those genera in which the ambulacral groove is thus covered no regular pinnules have ever been observed, and, moreover, the construction is such that no additional pinnulæ could have existed, while on the other hand no covering has ever been discovered in forms with true pinnulæ."

After I described the plates covering the ambulacral grooves in Glyptocrinus, notwithstanding the long flowing pinnules, I believe they modified their views, but, at present, I have no reference to the revised opinion. Their greatest mistakes seem to me to have arisen, however, from the use of the mongrel word "*underbasals*," and a complete misconception of the purposes subserved, in the animal economy, by the plates referred to, and the consequent neglect to give the basal plates the examination their importance demanded. They frequently discuss "rudimentary underbasals," when no such thing was ever found in a palæozoic crinoid, and from the structure of the calyx, and purposes subserved by the basal plates, "rudimentary underbasals" never could have had an existence in any of them. For instance, they say on page 7, second part, "Glyptocrinus was originally described with five basals and no underbasals. Hall afterward discovered in G. decadactylus small pieces concealed within the basal cavity, so rudimentary, however, that both he and Meek hesitated to call them basals, although both authors apply that term to the proximal plates in all other cases. Meek distinguished them as 'subbasals.' We have examined the plates in question very carefully in the species named, and find them, although very rudimentary, placed within the basal ring, hence they are according to our terminology, true underbasals, and not as Hall describes them, a 'quinquepartite' upper joint of the column." And again on page 186, second part, "Glyptocrinus differs from Glyptaster in having rudimentary instead of moderately developed underbasals." After I had shown that there were no such plates in Glyptocrinus, they admitted on page 102, third part, that the absence of underbasals in this genus "is clearly proved."

They said of Heterocrinus in the first part of Palæocrinoidea: "The absence of underbasals in some of the species is a good illustration of our views that the underbasals do not constitute elements in the structure of the Palæocrinoidea, but are merely the result of growth in geological time." Again they say: "Underbasals, minute in some species, almost undeveloped and appearing externally as subtrigonal points at the lower ends of the sutures between the basals; in some species apparently wanting entirely." But in the third part they state correctly that there are no underbasals in Heterocrinus, and having studied the genera belonging to the Heterocrinidæ, they defined them as monocyclic. It will be readily seen that where such crude and erroneous notions exist about the principal plates of a crinoid, and the same plates bear two different names, that the family classification must be imperfect, and governed by the whims of the various authors.

P. Herbert Carpenter had an opportunity of studying some living crinoids, after which, in his abuse of Dr. Hambach of St. Louis, he reasoned, through that conduit of English ignorance and conceit, "The Annals and Magazine of Natural History," as follows:

"I have the strongest conviction that the would-be interpreter of extinct fossil forms starts at a very serious disadvantage if he does not commence by obtaining the best possible information about the morphology of their nearest living representatives (as I have done). In order to understand, even with an approximate degree of correctness, extinct groups, such as the Blastoids, Merostomata, Dinosauria and others, a far more extensive acquaintance with the recent members of the same subkingdom is necessary than for the interpretation of fossil Brachiopoda, sponges, corals, Mollusca and fishes, the morphology of which can not have differed in any important respect from that of the recent species. Without such a preliminary study no collector, however zealous, can hope to arrive at any rational conclusion (as I can) about the functions of the different structures which he may discover by the careful examination of his fossils."

I have inserted the words in parenthesis to smooth down the application to Dr. Hambach, who was completely undone by this style of reasoning, for he thought his "extinct fossil forms" were living fossils, until P. Herbert Carpenter told him most emphatically, in parenthesis, that "Mr. Hambach has never seen a living Blastoid."

As examples of the effect his study of the "living representatives" has had on his "understanding" of the "extinct fossil forms," we may refer to his morphological statement that Hybocycstites combines Blastoid rather than Cystidean characters with those of crinoids. That Hoplocrinus is a synonym for Hybocrinus, notwithstanding there is only one azygous plate in the former, while there are two in the latter, and other important structural differences, and he at once proceeded to redefine the latter genus so as to include the former. And, speaking of Xenocrinus, he said: "I can not help suspecting that a better knowledge of this type (Xenocrinus) will lead to its absorbtion into Retiocrinus." He said: "Hybocrinus is a crinoid of a very embryonic type. The relatively large size of the basals and the retention of the anal plate, together with the simplicity of its arms, and the absence of pinnules, all indicate its low stage of organization." He regarded Baerocrinus "as a permanent larval form, which has only developed three of its five arms," and "Hoplocrinus is a persistent larval form." Wetherby illustrated and described the azygous plate of Hybocrinus as "rounded and crenulated at its distal extremity as well as much thickened." This the doughty Carpenter disposed of by saying he had received a specimen from Mr. Wachsmuth on which he could "make out little or no trace of crenulation."

It would not be necessary to point out his illiteracy, for he even uses capital letters for specific names, or lower-case, as it may happen, showing his want of a common knowledge of grammar, and recklessness in the symmetry of nomenclature, were it not for the fact that a mutual admiration society sprang up between him and Wachsmuth, and Wachsmuth adopted many of his blunders and republished them, thus giving currency to them throughout the country and injuring the progress of knowledge. It is true that Wachsmuth has refuted some of his vagaries and unwarranted conclusions, but he adheres to many of his innovations in nomenclature, though unwilling to go so far as to call all the regular interradial and vault plates oral plates and all the azygous plates anals.

The basal plates of a crinoid rest directly upon the column, and are truncated by the columnar canal, around which the animal was attached by ligaments, the scars of which are very frequently preserved. The subradial plates are never basals, nor are they in any sense homologous with the basals. In 1879, P. Herbert Carpenter, disregarding the original definition and illustration of Heterocrinus by Hall, and the equally plain illustration and positive statement of Billings that there were no subradial plates in the genus, or not having the sense to understand an illustration and definition, asserted there are subradials in Heterocrinus, and proposed to call the subradials, which had no existence, the "basal" plates, because he said they were the genital plates, and the basals he proposed to call the "*underbasals*," a mongrel word, part English and part Latin. This was a case of pure ignorance, assumption and conceit. Only one overgrown with self-conceit would propose to change the nomenclature in any branch of natural history, where no change is demanded in the interest of science, and only the most illiterate would propose in science a mongrel word formed from two languages, and only the most ignorant would select for the application of a new term an object which has no existence in nature whatever. The assertion that the subradial plates in any palæozoic crinoid are genital plates is purely gratuitous, and not warranted by any of the known facts relating to crinoids. It would have been equally as correct if he had asserted that the subradial plates were the seat of the soul, and he might have fortified the assertion by claiming that he had seen the blue ethereal substance floating around them. We were surprised, however, that he coined the word from English and Latin, for he affects profound learning in the German, and, like the politician enamored, during a campaign, of the "sweet German accent," he frequently quotes snatches from German authors, to make his usually poor English more incomprehensible. That he did not propose "*unterbasals*" for the basal plates of a crinoid, and thus make himself strong with the Germans, may have been an oversight, but if he had known the Indian tongue, he would have done himself proud by calling the basal plates "*hatapostlukbasals*," and he could have strengthened his position by commencing the word with a capital letter, as he does specific names.

Four years later he wrote that "most of the leading writers on the crinoids" had adopted his nomenclature for the plates of the crinoids, and he mentioned them. There were in all six persons, two of whom were from America, "Wachsmuth and Wetherby." It must have done the souls of Wachsmuth and Wetherby good to learn from such high authority that they constituted "most of the leading writers on crinoids," in this country. We learn from Wachsmuth and Springer's Palæocrinoidea, pt. 3, p. 8, that two years later Prof. Williams had joined this host of "most of the leading writers on crinoids," Wachsmuth and Wetherby. It may be in the additional five years that have elapsed since the name *underbasals*" was proposed, that others have used the word to add confusion to the definition of crinoids; but it is to be hoped that each one does not constitute "most of the leading writers on crinoids" in this country. And it is high time American palæontologists would cease to look to England for information, where less is known of its own fossil crinoids than happens to be the lot of any other country in which there is any pretention to palæontological knowledge, and where more shallow pretenders vent their stupid hypotheses as to the fossil tests of these animals than exist in any other land.

Prof. D. S. Jordan, in "Science Sketches," very appropriately says: "The chief aim of the law of priority, like that of the law of primogeniture, is not the survival of the fittest, nor yet justice, but simply fixity." And the application of this rule should prevent even the most over grown "big-head" from interfering with the long established names of the plates in the calyx of a crinoid, beside, there can be no more appropriate and truthful names than "basals" and "subradials." Subradial plates occupy a subradial position, they are neither radial nor inter-radial, but one half is below one radial series and the other half is below another radial series. Basals are always basals and never "underbasals." In some genera they are below the subradials, but in other genera the subradials extend below the basals, while the basals, in the interior of the calyx, project higher than the subradials.

There are no anal plates below the arms in the calyx of any palæozoic crinoid, and there is no more reason for calling the plates, in one interradial area, anals, in the present state of learning, than there is for calling them orals. The word "azygous" is applied to them because it is non-committal, and simply indicates that the plates are not the same as those in the other interradial areas. The opening in the azygous side of the vault or in the proboscis may be an anal opening, and, if so, the plates surrounding it or covering it might be called anal plates, but the name can not be applied properly to any other plates of the body. The course of evolution was progressive toward more complicated structures in crinoids, until the Subcarboniferous age; here they seem to have attained their most perfect existence. The living crinoids are the remnants, probably, of a long line of retrogression—the degenerate descendants of more highly organized ancestors—wherein some of their parts are of comparatively modern origin and others, which the ancestors possessed in a high degree, have wholly departed so that not even a rudimentary plate or scar is left to indicate the functions once exercised. Where progression has been the rule, in the development of any class of animals, we may look to the embryology and the growth of the young for reflected light on the fossil remains of past ages; but where the evolution has been backward for geological cycles of time, the study of embryology of the degenerate descendants sheds but little light, if any, on the primitive ancestry. To speak of a fossil crinoid as "a permanent larval form" or as an "embryonic type" is, therefore, unenlightened affectation.

The basals, in all palæozoic crinoids, were the first plates to become fully developed, and, after this, they retained the same position respecting the column, through all further stages of the growth of the animal, as is shown by the uniform projection of the basal disk beyond the column, in all specimens, large and small, in the same species. It is the practice in describing the form of the basal plates to ignore the side truncated by the columnar canal and treat the plates, in description, as if they came to a point at the center of the columnar canal, which is of course never correct, and to illustrate them by cutting off the lower end so that the plates united will leave a pentagonal opening, with the angles at the suture lines of the plates, which is never correct, In fact, I never saw a correct diagrammatic view of the calyx plates of a crinoid, though the basals united are sometimes correctly illustrated. The size and form of the truncation is dependent upon the shape of the columnar canal, but the angles of the canal never unite with the suture lines of the plates; on the contrary, the rays or angles of the canal truncate the plates, and the suture lines of the plates strike the sides of the canal or extend to the body of the canal between the rays.

Wetherby described the basal plates of Pterotocrinus as excavated for the column and thickened and carinated at the outer edges of the columnar excavation, and I infer, from what he said, that his specimens also preserved the evidences of ligamental attachments around the canal. In the "Description of some new genera and species of Echinodermata, from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri and Iowa" by myself and Mr. Gurley, it was shown that the base of Ulocrinus is strengthened by the thickening of the plates around the part to which the column attached and by the anchylosis of the basal plates. There is an external circular depression into which the end of the column was inserted, and this depression is surrounded by a rim to afford further strength to the point of union between the column and the body of the crinoid. At least three plates of the column were inserted into this circular depression, one of which had an extended rim beyond the column that filled a circular furrow on the interior of this depression which locked the column in the basal plates. The first plate of the column at the base of this circular depression is thin and radiately ridged to interlock with the second plate. The rays of the opening on the internal side of these plates are flanged so as to enlarge the end of the columnar canal as it passes through the basal plates. This enlarged opening is surrounded by a rim for some kind of muscular attachment and to give strength to this part of the calyx. On the outside of this rim there are radiating ligamental furrows or vascular markings for the attachment of the animal sarcode.

These characters are well shown by the illustrations. The basal plates of Eupachycrinus magister are also illustrated, showing the conical elevation in the interior of the calyx pierced at the summit by a five rayed opening for the columnar canal, with the rounded ends of the rays truncating the plates. The pentagonal opening is surrounded with ligamental scars or radiating ligamental lines, while the other parts of the internal sides of the plates are smooth. I have seen the same evidence in the basal plates of Delocrinus. I have the basal plates of Glyptocrinus showing the thickening of the plates internally around the five rayed canal and bearing evidences of ligamental attachment. It is well known that the end of the column, in all palæozoic crinoids, is so firmly attached to the basal plates, that it is rare to find a good specimen where the column has been separated from the basals leaving the place of the columnar attachment in a good state of preservation. I have before me a Batocrinus, with a hemispherical depression at the base, which is radiately furrowed surrounding the pentagonal opening for the columnar canal, for the firmer attachment of the column. I have a specimen of Anomalocrinus showing the anchylosis of the upper joints of the column and of the column with the basals, and after examining specimens in different genera, I have concluded it is not uncommon for the plates of the column, at the upper end, to be anchylosed together. The only ligamental scars in the calyx of any crinoid thus far discovered surround the columnar canal. It follows, therefore, that the basal plates are the most important in classification of any of the plates of the calyx, because the animal was attached to them, while the other plates subserved the inferior purpose of simply enclosing the other parts of the animal sarcode.

It must be apparent, therefore, that there can be no "rudimentary basals," none that are developed from the upper stem-joint, and none except they are large enough to surround the columnar canal and with area enough for the muscular attachment. The anchylosis of the basal plates is as common in genera, having no subradials as it is in those having them. It would appear that the attachment of the column to the basal plates, the passage of the columnar canal through them, and ligamental attachment on the interior held the basal plates firmly in one position, and while, in their younger state, they were capable of growing and conforming to the alternate arrangement of the plates of the column and the succeeding plates, that, in their more advanced state, the growth terminated in secreting the material that anchylosed the plates.

The earliest crinoids had five basals and such forms continued to exist throughout palæozoic time. Those having four basal plates appeared in the latter part of the Lower Silurian and disappeared in the Devonian age. Those having three basal plates appeared in the Lower Silurian and disappeared with the Subcarboniferous, and those having only two basal plates are confined to the Subcarboniferous and Coal Measures. This statement also tends to prove the significance of the basal plates, in classification, beside, the form of the basal disk must, in all cases, control more or less the number of the succeeding plates and the structure of the calyx and body of the crinoid. For these reasons, the number of basals and the shape of the basal disk are of the first importance, and families should be so formed as to include only genera having the same number of basals and substantially the same form of the basal disk.

The second character of family importance will be found in the presence or absence of subradial plates. The only known function performed by the subradials is to increase the capacity of the visceral cavity surrounding the area of ligamental attachment to the test. In some genera, they cover half the calyx below the arms, and, in all cases, they materially affect the form and structure of the calyx and body of the crinoid. Where the plates are large, they were supported in position by ligaments in beveled sutures, as in Eupachycrinus, or by peculiar denticulated or serrated edges such as are found in Arthracantha, as illustrated and definded by Hinde, or in Ulocrinus as figured and described by myself and Gurley. For the purpose of classification, therefore, no family should include genera having subradials and those in which they do not exist.

The next family character will be found in the presence or absence of regular interradial plates. These plates allow breadth to the body, and though, in their extension over the vault and in other respects, they may sometimes sink to generic or specific importance, yet the fact of their presence or absence is always of family value. The position of the first interradial is of high classificatory value, and genera supporting the first interradials on the basal plates are never to be associated, in the same family, with those supporting the first plate between the upper sloping sides of the first radials.

The next, in family importance, are the azygous plates. The structure in this part of the body is frequently complicated and is always of generic importance and frequently of family value. For instance, a genus having an azygous plate resting on the basals is not generally to be classed, in the same family, with one having the azygous plate truncating a subradial, for the whole structure of the azygous side of the genera is different in these cases, commencing with the position of the first plate.

I regard each plate in the calyx of a crinoid to which I have attached family importance, as an independent morphological element, and, except in the specimen figured from my collection, in Ohio Palæontology, by Meek, under the name of Anomalocrinus incurvus, where there occurs an extra basal plate below the termination of a suture dividing a radial, I have always found the plates the same in each genus.

The structure of the arms, I think, is never of family importance, and above the brachials never of generic importance, though always of specific value. An illustration or two will suffice for the demonstration of this opinion. In Dichocrinus we have a species with small subquadrangular pieces forming simple arms, another with arms composed of rather large cuneiform plates, and another with arms composed of a double series of interlocking plates. In Poteriocrinus the species have arm varying in number from ten to fifty, and the structure of the arms varies almost as much as their number does.

The shape of the column is probably of generic value. The vault and proboscis have characters of family value, but they are too little understood to base any general classification upon them. But, where they have been investigated, they afford additional evidence in support of the families established on the structure of the calyx as herein above indicated.

We will now briefly define the families based upon the structure of the calyx, without, however, undertaking to fully define them by adding all the family features that may be discoverable in the vault and column.

GENERA HAVING TWO BASALS.

FAMILY, Dichocrinidæ.—Cyotledonocrinus, Dichocrinus, Talarocrinus.

The calyx is obconoidal. Two basals form a cup slightly notched at the sutures. No subradials. Small, regular interradials on the truncated top of the first radials. Five long radial plates in the first series, succeeding radials small and resting only on part of the upper side of the first radials, the rest being occupied with interradials. Azygous plate in line with the first radials, of about the same size, supported in a notch at the sutures of the two basals, and followed by the plates of the vault. Vault more or less convex or elevated, with a subcentral opening on the azygous side. Column, so far as known, round.

FAMILY, Pterotocrinidæ.—Pterotocrinus.

Calyx saucer-shaped. Two basals form an eight sided shallow disk, notched at the sutures. No subradials. No regular interradials. First radials large, expanding from a wide base and resembling in outline the side view of an expanding bucket. The top of each first radial supports two second radials and part of two more, which rest, in part, upon the first mentioned second radials. Tertiary radials unite laterally around the top of the calyx. Azygous plate rests in a notch at the sutures of the basals, is pointed above and completely embraced by the first radials. Vault pyramidal, pentagonal, the azygous side wider than the others, the top bearing five long, peculiar, paddle-like plates arranged star-like and directed at right angles to the body, with the ends of the four arms resting in each of the angles of the five rayed dome or vault covering. Column round.

FAMILY, Acrocrinidæ.—Acrocrinus.

Calyx urn-shaped, composed of plates that increase in size from the basals up. Basals two, comparatively large, forming a polygonal shallow cup, followed, in Acrocrinus wortheni, by twelve minute, triangular plates all of which are subradial and subinterradial in position; these are followed by twelve larger plates, united by their lateral sides, five of which are radial in position and seven interradial, three of which are the azygous area; these are followed by a third ring consisting of fourteen plates, all of which are subradial and interradial in position; a fourth ring consists of sixteen plates, five of which are radial and the others interradial. Above the fourth ring there are two or more radials in each ray separated by interradials, all within the calyx. The number of plates in the calyx of different species varies from 100 to 700. In Acrocrinus shumardi, the type of the genus, instead of four rings of plates, as above defined, there are fourteen or more rings, some of which have twenty-five or thirty plates. Above these rings of small plates there are 3x5 radials, each series being separated by two or more series of interradials; the azygous area being wider and containing more plates than the others; there are also secondary radials.

The numerous rings of plates, between the basals and the commencment of the continuing series of radials, is peculiar to this genus and family, and at once distinguishes it. If the rings were united, they would occupy the position of subradials, or subradials and interradials, but such is the arrangement, that we know of no rule, which authorizes them to be treated as if united.

The three families, Dichocrinidæ, Pterotocrinidæ and Acrocrinidæ, having only two basal plates, are widely disconnected, and each one is so far removed from all other families that no one can be pointed out which is more nearly related to them or either of them than another. We can not infer they descended one from another, or that either of them was developed from any particular family of crinoids having three, four or five basals. We may be ever so fond of the theory of the evolution of animals and the doctrine that embryology reproduces the images of the lines of descent in geological time; but we may stop when we encounter numerous plates, in the calyx of a crinoid, whose relation and homology with plates in other crinoids we can not understand until "missing links" are discovered, before professing to have knowledge of the ancestral type.

GENERA HAVING THREE BASALS, NO SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Synbathocrinidæ.—Synbathocrinus.

Calyx small, cup-shaped. Basals three, the two larger equal, pentangular, the smaller one quadrangular. No subradials. No regular interradials. Radials 1x5, truncated and thickened above. Azygous plates resting upon one radial and between the brachials, forming a straight, narrow series of two or more plates. Brachials resembling the first radials reversed. Arms five, long, folded together, enclosing a slender proboscis composed of five rows of quadrangular plates. Column round.

FAMILY, Calceocrinidæ.—Calceocrinus, Deltacrinus, Halysiocrinus.

Calyx laterally flattened and hanging down from the column. Basals three, two are equal and form together a lunate piece, and the other plate lies within the concave side so as to make the long side of the subtriangular or half elliptical basal disk. Plates always anchylosed. The cicatrix for columnar attachment is in a lateral position in the center of the two equal plates, and does not touch the other plate. No subradials. No interradials. Calyx above the base consisting of five to seven plates, four of which are radials of unequal size and irregular arrangement.

GENERA HAVING THREE BASALS, NO SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, Actinocrinidæ.—Actinocrinus, Agaricocrinus, Alloprosallocrinus, Amphoracrinus, Batocrinus, Dorycrinus, Eretmocrinus, Gennæocrinus, Megistocrinus, Physetocrinus, Saccocrinus, Steganocrinus, Strotocrinus, Teleiocrinus.

Calyx varying from concave, as in Agaricocrinus, to obconoidal, as in Actinocrinus. Basals three, equal, having a hexagonal outline. No subradials. Primary radials 3x5, secondary radials more or less numerous, tertiary radials in some genera. Regular interradials more or less numerous, the first one resting upon the upper sloping sides of the first radials; sometimes intersecondary and intertiary radials. Azygous area larger than the regular interradial areas, the first plate resting upon the basals, in line with the first radials and of similar form. Column round.

The learning in regard to the respiratory openings in this family is well illustrated, by the statement of Wachsmuth & Springer, on page 11, part I, of their work, that they had "noted the existence of certain pores or openings located between the arm bases and separated from the arm passages by a thin partition. Their number varies from ten to twenty or more. In Batocrinus where they are most conspicuous, there are twenty, no matter whether the species has more or less than twenty arms. They are about one-third the size of the arm passages, with which they are in very near the same horizontal plane." And the statement, on page 51, part II, where they say, in this, "they were evidently in error; the pores probably always agree in number with the arms, and are really neither radial nor interradial, but are placed at the base of the arms."

FAMILY, Platycrinidæ.—Coccocrinus, Cordylocrinus, Eucladocrinus, Macrostylocrinus, Marsupiocrinus, Platycrinus.

Calyx sub-globose to urn-shaped. Basals three, two of them equal, the other smaller, forming a pentagonal disk or cup. No subradials. First radials very large forming the greater part of the test of the calyx, the upper face of each bears a short or concave facet for the articulation of the second radials. Second, and also third radials, when they exist, small and short. Interradials and azygous interradials rest upon the first radials and are substantially alike in the different areas, column round or elliptical.

In Macrostylocrinus, there are 3x5 primary radials, and the first interradials are between the second primary radials, and smaller interradials occur between the third primary radials, all of which form part of the calyx below the arms, and, in this respect, it differs from other Platycrinidæ, where the interradials do not connect the second and third primary radials and approaches the structure of the Actinocrinidæ. It has little structural affinity with the Melocrinidæ which have four basals, and to which Wachsmuth referred it. But Wachsmuth disregarded the number of basals to a great extent in arranging and defining the families, and his definitions are so loose that crinoids, belonging to distinct and widely disconnected families, may be thrown together in hodge-podge. For example his definition of the Melocrinidæ is as follows:

"Melocrinidœ. Base monocyclic. Basals 3 to 5. Neither anal nor interradial plates touching the basals; the latter in contact with radials only. Interradial areas composed of numerous plates; those upon the dorsal side large, regularly arranged; those along the ventral surface frequently small and irregular. Oral plate generally surrounded by proximals. Anus sub-central. Column circular, rarely angular."

FAMILY, Dolatocrinidæ.—Allocrinus, Dolatocrinus, Hadrocrinus, Stereocrinus.

Calyx, basin-shaped, or somewhat hemispherical, depressed at the base. Basals, three, usually anchylosed so as to create doubt as to the number. No subradials. Primary radials 2 or 3x5; secondary radials two or more by ten, tertiary radials sometimes present. Azygous and regular interradials areas alike. Interradials, three or more, the first resting between the upper sloping sides of the first radials, the larger, and generally the largest, plate in the calyx, truncated on top for the second interradial which bears smaller plates. Arm openings, large. Small subcentral proboscis. Column, round.

Wachsmuth & Springer refer the genera in this family to the Melocrinidæ. Dolatocrinus was supposed by Lyon to have five basal plates, but Wachsmuth and others assert it has only three, and it is upon their statements, in this regard, that this family is founded, for I have never seen a specimen that preserved the basals, though I have imperfect specimens of Dolactocrinus lacus and would guess from an examination of them that they have only three basals.

FAMILY, Arthracanthidæ.—Arthracantha.

Calyx, cup-shaped. Basals, three, subequal, hexagonal in outline. No subradials. First radials subequal, very large, forming the greater part of the test of the calyx, each one thickened in the middle and having a concave, ridged facet for the articulation of the second radial, which is a short quadrangular plate reaching but little above the margin of the first radial; third radial short, pentagonal, and bearing the free arms. Regular interradials consist of three zones of three or four plates each, in each area, resting upon the first radials and between the second and third interradials. The middle plate in the zone resting upon the first radials is the larger one, and the plates on either side of it are larger than those above. The first azygous plate rests upon two basals in line with the first radials and is nearly as large, but a little narrower at the upper margin, which is on a level with the first radials. Above this plate, in the azygous area, there are three zones of plates; in the first zone there are six and in succeeding zones seven; column, round. All the plates of the calyx bear articulating spines, the bases of which are perforated with a minute circular pit as in the Echinida, and as Hambach determined in some, Blastoidea. This character alone is probably of family importance, as it is not known to exist in any other family of crinoids, living or fossil. Otherwise the basals, first radials and first azygous plate would ally it with the Actinocrinidæ and the plates above with the Platycrinidæ.

Wachsmuth & Springer classed this family with the Dichocrinidæ and Pterotocrinidæ, in one family, which they called Hexacrinidæ. There are not three families, in my opinion, farther removed from each other in all the Palæocrinoidea. Their family definition is as follows:

"Hexacrinidæ. Base monocyclic. Basals 2 or 3. First anal plate resting on basals and similar in form to first radials; other plates arranged as in Platycrinidæ. Calyx with similar arm-like extensions. Column circular."

Let us see what there is in this family definition. 1st. They say, "base monocyclic." So is the base in every crinoid that has no subradials. In other families they include monocyclic and dicyclic crinoids, which embrace nearly the whole order. 2d. "Basals 2 or 3." This disregards the number of basals as a family character, and, in another part of their work, they say the number of basals can not be considered as of family importance; and yet, crinoids having only two basals are unknown in rocks as low as the Devonian, and Arthracantha is exclusively a middle Devonian genus. 3d. "First anal plate resting on basals and similar in form to first radials." It is the same in the Actinocrinidæ. 4th. "Other plates arranged as in Platycrindæ." Such is not the case in the Pterotocrinidæ, by any stretch of the imagination. 5th. "Calyx with similar arm-like extensions" This can not be true for they include arms constructed of single and double series, arms widely separated and closely compacted; arms free, flowing, and those confined in interbrachial angles, and in short, almost every form is represented. 6th. "Column circular." This is the case in nearly every family.

GENERA HAVING THREE BASALS, SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Ichthyocrinidæ.—Ichthyocrinus, Lecanocrinus, Mespilocrinus.

Calyx obconoidal to sub-globose. Basals three of unequal size. Subradials five, pentagonal and hexagonal. Primary radials 2, 3 or 4x5. Secondary radials more or less numerous, and higher bifurcating series abutting laterally. No regular interradials. Azygous interradials usually absent in Ichthyocrinus, one subquadrangular and resting upon the larger basal, as in Mespilocrinus, or two, one of which rests obliquely in the angle formed by the upper sloping sides of two subradials on the right, and the other truncating the subradial on the left, as in Lecanocrinus.

FAMILY, Ampheristocrinidæ.—Ampheristocrinus, Closterocrinus?

Calyx obpyramidal. Basals three, two truncated on top, the other much smaller and angular above. Subradials five, two hexagonal, two pentagonal, and one heptagonal, the latter the larger one. Primary radials, one in each series, with a small central concavity for the reception of a second plate, as in Platycrinus. No regular interradials. Azygous area large, having six or more plates, the first one rests obliquely upon the right upper sloping side of the heptagonal subradial and the under sloping side of the right first radial, the second one truncates the same subradial, and these bear smaller interradials. Closterocrinus is referred with some doubt to this family. Wachsmuth referred Ampheristocrinus to the Cyathocrinidæ and did not mention Closterocrinus.

Genera Having Three Basals, Subradials, and Regular Interradials.

Family, Taxocrinidæ.—Forbesocrinus, Onychocrinus, Taxocrinus.

Calyx saucer to cup-shaped. Basals three, of unequal size. Subradials five, unequal. Primary radials more or less numerous, the first one sometimes reaching as low as the basals and completely disconnecting the subradials. Regular interradials from one to twenty or more. Azygous area larger than the regular interradial areas and plates more numerous, the first plate in some genera truncates a subradial, and in others rests between the upper sloping sides and the first radials.

In Taxocrinus subovatus the basals form a pentagon extending beyond the column, the subradials are small triangular plates, separated from each other, so as to allow the first radials to rest upon the basals, at the central part, with under-sloping sides abutting the adjacent subradials.

Genera Having Four Basals, No Subradials, Regular Interradials.

Family, Eucalyptocrinidæ.—Eucalyptocrinus, Hypanthocrinus.

Calyx bowl-shaped to obconoidal with depressed base. Basals four, one larger than the others, deeply sunken in the basal cavity and developed in the interior. No subradials. Primary radials 3x5; secondary radials 2x10; tertiary radials 1x20. Interradials three, the first one is the largest plate in the calyx, and always has ten sides; the other two are separated by a verticle suture and their upper ends extend to the top of the tertiary radials, where they support long, flat, interbrachial plates; intersecondary radials, in form like the two upper regular interradials, in like manner extend to the top of the tertiary radials and support long, interbrachial plates. Azygous area like the other interradial areas. Interbrachial plates extend from the top of the interradials as high as the arms reach, where they unite with the summit plates. Column round. After a re-examination of the fossils, I think the genus Hypanthocrinus should be restored to receive those forms with a proboscis extending beyond the arms and summit plates.

Family, Melocrinidæ.—Compsocrinus, Mariacrinus, Melocrinus, Technocrinus.

Calyx bowl-shaped to obconoidal. Basals four, unequal. No subradials. Primary radials 3x5; secondary radials more or less numerous, and sometimes, as in Compsocrinus, many tertiary radials. Interradial, intersecondary and intertertiary areas more or less flattened or depressed. First regular interradial resting upon the upper sloping sides of the first radials, followed by two plates and these by three, above which the plates are more or less numerous. Azygous area wider than the regular areas, the first plate resting upon a basal or between the first radials, and generally followed by three plates, and these by three or four, above which they are more or less numerous. Vault variable. Column round, as in Melocrinus, or quadrangular with depressed sides, as in Compsocrinus. It is not without some doubt that Compsocrinus is referred to this family, because the azygous side, upper part of the calyx, and the column are quite different from other genera. Technocrinus is also doubtfully referred to this family, because in it, the azygous area is like the other areas, and the upper part of the calyx is widely different from Melocrinus.

FAMILY, Xenocrinidæ.—Xenocrinus.

Calyx, obpyramidal, sides depressed. Basals four, unequal, uniting at the angles of the column. No subradials. Primary radials 3x5, long, flanged on both sides; secondary radials, four or more in each series of the same form. Interradial and intersecondary radial areas, depressed and covered with numerous very small plates. The first interradial generally rests upon a basal, but in some cases it is separated therefrom by a narrow prolongation of the flanges near the lower part of the first radials, and hence, rests upon the lower part of and between the first radials. Azygous area contains a vertical series of long plates, nearly as long as radials, in its central part, supported upon a basal plate and extending beyond the calyx, and on each side of it there are numerous very small plates, as in the regular interradial areas. Column quadrangular, but sometimes becoming round below. Columnar canal pentagonal.

GENERA HAVING FIVE BASALS, FIVE SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Cyathocrinidæ.—Abrotocrinus, Arachnocrinus, Bursacrinus, Carabocrinus, Cyathocrinus, Graphiocrinus, Palæocrinus.

Calyx saucer, hemispherical or bowl-shaped, depressed below. Basals five, equal, varying from a flattened disc to a cone in the interior of the calyx. Subradials five, large. Primary radials 1x5, large; the one on the right of the azygous side, usually the smaller one, truncated on the top, and usually having a concave facet in the central part of each for the support of the brachials, but in Abrotocrinus, Bursacrinus and Graphiocrinus, the articulation is upon the whole upper horizontal face, as in Poteriocrinidæ, with an external gaping suture. No regular interradials. Azygous plate resting upon the upper edge of a subradial and between two radials. Column round or pentagonal.

Carabocrinus is included in this family on the supposition that Billings was mistaken in saying the azygous area has three plates instead of one. If, however, his diognosis was correct the genus would belong to another family.

I have separated from the Cyathocrinidæ the Poteriocrinidæ, on the ground of the increased number of plates in the azygous area, and the fact that one of them rests upon two subradials, and another upon one; confining the Cyathocrinidæ to those having a single azygous plate truncating a subradial. If this distinction is not of family importance, then the Poteriocrinidæ should be associated with the Cyathocrinidæ, as most authors have done. As a general rule the calyces of the Poteriocrinidæ are obconoidal from the attachment of the column up, and the bases of the Cyathocrinidæ are sunken, giving the calyces a bowl-shape, but this rule has its exceptions, so that families can not be based upon it.

FAMILY, Poteriocrinidæ.--Atelestocrinus, Barycrinus, Coeliocrinus, Euspirocrinus, Goniocrinus, Homocrinus, Hydreionocrinus, Poteriocrinus, Scaphiocrinus, Vasocrinus, Zeacrinus.

Calyx obconoidal to bell-shaped. Basals five, equal, forming a flattened disc or low pentagonal cup, with high angles between the subradials. Subradials five, unequal. Primary radials 1x5, horizontally truncated upon the upper face for the articulation of the brachials. No regular interradials. Azygous interradials two or more, the first one resting between two upper sloping sides of subradials and below the under sloping side of the first radial on the right, the second one abutting upon the first, truncating a subradial and abutting upon the first radial on the left. In such genera as Barycrinus this plate also abuts upon the first radial on the right and extends to the top of the calyx. But in genera having three azygous plates the third one rests upon the first, abuts upon the second one on the left and the first radial on the right; and if a fourth plate exists it rests upon the second, abuts the upper part of the first radial on the left and the first brachial and the third azygous plate on the right. Where three or more plates form part of the calyx they are arranged alternately in two rows, and continue into and form part of the ventral sac or proboscis.

I have classed Hydreionocrinus and Zeacrinus in this family with some doubt. They differ in the general construction of the vault and in the arrangement of the azygous plates from other genera, and probably they constitute a separate and distinct family, though I believe all American authors have classed them with Poteriocrinidæ.

FAMILY, Dendrocrinidæ.—Dendrocrinus, Ottawacrinus.

Calyx obconoidal. Basals five, equal, forming a low pentagonal cup. Subradials five, unequal. Primary radials 1x4 and 1x2, horizontally truncated or having a concave facet for the articulation of the arms. No regular interradials. Azygous interradials one, truncating a subradial followed by a double series of plates that graduate into the proboscis. This family is distinguished from the Cyathocrinidæ and Poteriocrinidæ by having two primary radials on the right of the azygous plate instead of one. Otherwise the form of the calyx is like that of a Poteriocrinus and the azygous plate like that of a Cyathocrinus. The many species of Dendrocrinus and variety of forms lead to the separation into a family, for convenience of classification, beside no Poteriocrinus is found in the Lower Silurian rocks, where Dendrocrinus prevails, and only one rare genus (Euspirocrinus), referred to the Poteriocrinidæ, exists in the rocks of that early age.

FAMILY, Eupachycrinidæ.—Æsiocrinus, Delocrinus, Eupachycrinus, Ulocrinus.

Calyx, somewhat hemispherical, flattened or depressed at the base. Basals, five, equal, sometimes forming an interior cone. Subradials, five, very large. No regular interradials. From one to three azygous interradials, when only one exists, it truncates a subradial and rests between first radials, as in Cyathocrinus, but when two or more exist they are arranged much like they are in Poteriocrinus, though the first plates situate between the upper sloping sides of the subradials and below the primary radial on the right, may be larger than a primary radial, which is never the case in the Poteriocrinidæ. The primary radials are truncated at the upper edge, and have a straight hinge line from one junction of the plates to another for the articulation of the first brachial plates, which are generally spine-bearing. The primary radials, when viewed from the interior, are arched over part of the visceral cavity, but as seen from above they extend beyond articulating hinges toward the center of the vault, as a platform, upon which the proboscis is supported. There are no vault plates in this family. The azygous plate at the top of the calyx extends its flange over the visceral cavity like a primary radial and supports a series of plates that make an azygous side to the proboscis. I have placed in this family genera differing in the azygous area and in the number of azygous plates, but the calyces are similar in form, otherwise, and the primary radials are alike in the articulating hinge, for the brachials and flattened surface or platform within for the support of the proboscis, which I consider of high importance in the structure of the internal anatomy. The column is round, the columnar canal five-rayed, and in the interior of the calyx it is surrounded with muscular scars, and the basal plates are anchylosed in all the specimens I have examined in this family.

Wachsmuth & Springer referred this family to the Cyathocrinidæ in the first part of their book, but in the third part they refer the genera to the Poteriocrinidæ.

FAMILY, Erisocrinidæ.—Erisocrinus, Menocrinus, Stemmatocrinus.

Calyx, somewhat hemispherical or globose. Basals, five, equal. Subradials, five, equal. Primary radials, five, equal. No regular interradials. No azygous interradials. In Erisocrinus and Stemmatocrinus the primary radials have the form of those in Eupachycrinidæ, but in Menocrinus they are like those in Cyathocrinus. This family is distinguished from both, however, by not having an azygous plate within the calyx which, I suppose, necessarily involves important structural modifications in the internal anatomy of the animal.

Menocrinus (Lecythiocrinus) adamsi, as illustrated by Worthen (Ill. Geo Sur., vol. VII, pl. XXX, fig. 8), has five basals, but M. olliculiformis, as defined by White, possessed only three basals. White had only a single specimen, and some imperfection may have misled him, for if it possessed only three basals the two species are not congeneric, and the latter could have no near affinity with any defined family, as Taxocrinidæ is the only one having three basals and five subradials.

Wachsmuth & Springer, in the third part of their work, refer Menocrinus to the Cyathocrinidæ. In the first part of their work they refer Erisocrinus and Stemmatocrinus to the Cyathocrinidæ, but in the third part they refer them to Poteriocrinidæ.

FAMILY, Agassizocrinidæ.—Agassizocrinus.

Calyx conical or urn-shaped. Basals five, thick, usually anchylosed, very small internal cavity, in which there are ligamental pits. Subradials five, large, thick. Radials 2x5. No regular interradials. Azygous interradials three or four, supported upon the basals. In the early stage of life Agassizocrinus possessed a small column, but in later life even a cicatrix for the columnar attachment is obliterated. I do not use Astylocrinidæ, because it was founded upon Astylocrinus, which is a synonym for Agassizocrinus, and as the generic name falls into synonymy, so does the family name. Wachsmuth & Springer use Astylocrinidæ.

FAMILY, Merocrinidæ.—Merocrinus.

Calyx very low, broad at the base, slightly expanding. Basals five, low, wide. Subradials five, short, wide. Radials 1x4 and 1x2, one radial series having two plates, the upper one of which is axillary, and supports on its right sloping side a brachial series, and on the left a smaller series that enters into and forms part of a proboscis, and in this respect the arrangement of the plates is like an Iocrinus. No regular interradials. No azygous interradials. Brachials numerous.

GENERA HAVING FIVE BASALS, FIVE SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, Gaurocrinidæ.—Gaurocrinus, Retiocrinus.

Calyx obpyramidal, depressed in the interradial and intersecondary radial areas, and having strong radial ridges. Basals five. Subradials five. Primary radials 3x5. Secondary radials from 2 to 6x10. Regular interradial areas filled with numerous small plates resting upon the subradials. Secondary interradial areas filled with numerous small plates. Azygous area larger than the regular areas, and supported by a ridge up the middle series of plates, somewhat like a radial ridge. Vault covered by small plates, which are continued as a covering over the arm furrows. Column pentagonal, with sides more or less depressed.

Family, Rhodocrinidæ.—Archæocrinus, Goniasteroidocrinus, Lyriocrinus, Rhaphanocrinus, Rhodocrinus.

Calyx subglobose or hemispherical. Basals five, forming a flattened disc or developed as a cone in the interior. Subradials five, equal. Primary radials 3x5. Secondary radials 1 to 4x10. Regular interradial areas wide, plates large, the first one resting upon a subradial and between the first primary radials. Azygous area like the regular areas except an occasional extra plate or two, without disturbing the general symmetry of the calyx.

It is not without some doubt that Archæocrinus and Rhaphanocrinus are referred to this family.

Family, Glyptasteridæ.—Glyptaster, Lampterocrinus, Thysanocrinus.

Calyx obpyramidal to cup or urn-shaped. Basals five, equal. Subradials five, four of them equal, the other one truncated for the support of the first azygous plate. Primary radials 3x5. Secondary radials variable in number in different genera. Interradial areas flattened or convex; plates large, one in the first series resting between the upper sloping sides of the first radials, two in the second and smaller ones above. Azygous area wider, the first plate resting on a subradial, is followed by three plates, and these by three, four or more in succeeding ranges.

Genera Having Five Basals, No Subradials, Regular Interradials.

Family, Glyptocrinidæ.—Cupulocrinus, Glyptocrinus, Pycnocrinus, Schizocrinus, Siphonocrinus. (?)

Calyx obpyramidal. Basals five, equal. No subradials. Primary radials 3 or 4x5, the last one supporting secondary radials, and sometimes tertiary radials exist within the calyx. Interradial areas more or less flattened. Regular interradials more or less numerous, the first one resting between the upper sloping sides of the first primary radials, this is followed by two plates, and there are three or more in succeeding series. Azygous area wider and containing more plates than the regular areas, though commencing with one between the upper sloping sides of the primary radials.

I am inclined to think that Siphonocrinus should be classed in another family, because the first azygous plate rests upon the basals, and for other structural differences. It is placed here only provisionally.

FAMILY, Cleiocrinidæ.—Cleiocrinus.

Billings described Cleiocrinus as having five basal plates between the first radials, and forming a belt at the end of the column. I reproduced his illustration in North American Geology and Palæontology. Wachsmuth correctly asserts that "such a structure has never been found in any crinoid." I believe with Wachsmuth that the plates supposed to be basals by Billings are interradials, but beyond this I can not follow him. He believes this genus had three very small basals and five small subradials, and he has given us an illustration of his views, which obliterates the columnar canal. I am unable to understand why he should suppose there are three basals and five subradials when such a structure is wholly unknown in the Lower Silurian rocks. Indeed three basals, five subradials, regular interradials and azygous interradials are known to exist only in three genera, and they belong to the Subcarboniferous age. I suppose Cleiocrinus had five basals and no subradials. And even with this structure it would be so far removed by reason of the arrangement of the plates constituting the calyx that it would constitute a distinct family.

GENERA HAVING FIVE BASALS, NO SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Heterocrinidæ.—Ectenocrinus, Heterocrinus, Iocrinus, Ohiocrinus.

Calyx obconoidal. Basals five, unequal. No subradials. No regular interradials. Azygous interradials not reaching the basals, but resting upon the upper sloping sides of the first radials. Primary radials irregular, and varying in number, in the same genus, the right posterior radial in some cases resting upon an azygous plate, and in Iocrinus a radial plate supports on its right sloping side a series of brachial plates and on its left a series of quadrangular plates that graduate into and form part of the proboscis or ventral tube.

FAMILY, Anomalocrinidæ.—Anomalocrinus.

Calyx, saucer or cup-shaped. Basals, five. No subradials. No regular interradials. A subquadrangular azygous plate situate between the lateral sloping sides of the two first radials, unites with them by a serrated edge and curves over toward the vault. One primary radial in three rays and two in each of the other two rays. The arms are wide apart and the radials, between the arms, curve over the edge of the vault. There is only one genus known. The calyx is low and wide, plates large, column large, different from any other known, arms also differing from all others and bearing pinnules only on one side, from one arm bifurcation to the next, alternately.

The diagram of Anomalocrinus incurvus by Meek, in the Ill. Geo. Sur., vol. 3, p. 327, and reproduced in my work on North American Geology and Palæontology, p. 324, is incorrect, if the specimen figured in the Ohio Palæontology, vol. 2, from my collection, under the same name, belongs to the same species. The columnar canal is large and five-rayed. The second and third azygous plates form a part of the vault covering.

FAMILY, Belemnocrinidæ.—Belemnocrinus.

Calyx, cup-shaped. Basals, five, large, long, narrow and of irregular shape, enclosing a very small visceral cavity. No subradials. Radials 1x5 smaller than basals. No regular interradials. Azygous plate like a radial, in line with them, resting upon a basal between two radials and supporting a ventral sac.

FAMILY, Catillocrinidæ.—Catillocrinus.

Calyx, bowl-shaped. Basals, five, forming an irregular pentagon, three of the sides being much the longer. Radials 1x5, very irregular in form and size, the two larger ones constitute three-fourths of the circumference at the top of the radials, but are narrow below, while the others diminish in width upward. The arms rise directly from the truncated summit of the radials and are quite compact, so that some radials support a much larger number of arms than others do. No regular or azygous interradials.

FAMILY, Hybocrinidæ.—Hybocrinus.

Calyx bulged or tumid on one side. Basals five, large. One plate half subradial in position, in line with four first radials, but not extending quite so high and bearing upon one upper sloping side a radial, and upon the other an azygous plate which is rounded and crenulated at its distal extremity, as well as much thickened. No regular interradials.

FAMILY, Haplocrinidæ.—Allagecrinus, Haplocrinus.

Calyx cup-shaped. Basals five. No subradials. No interradials. No azygous plates. Primary radials 2x3, plus 1x2, with small protruding concave facets in the upper truncated sides for the attachment of the arms; the upper face of these plates support five vault plates that form a pyramid over the visceral cavity of the calyx. The sutures of the vault plates are beveled, shallow in the lower part, wider and deeper above, and truncate the top of the pyramid.

Carpenter regards Haplocrinus as "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." Wachsmuth & Springer fully agree with him that Haplocrinus is "a persistent larval form, but do not understand how the five large plates can represent the orals in a Palæocrinoid." Neither does any other one. The permanent larval form is equally absurd.

Wachsmuth & Springer refer Allagecrinus to the Haplocrinidæ, while Etheridge & Carpenter referred it to the family Allagecrinidæ, and I followed the latter in my work on North American Geology and Palæontology, but probably the former are correct.

FAMILY, Pisocrinidæ.—Pisocrinus.

Calyx globular. This family has five basal plates, forming a subequilateral triangle, in the type species, three are triangular and two are quadrangular, but in the American species this is reversed. In the type species, two plates unite in an angle of the triangle, and only one side of the triangle is formed by three basal plates, the other two sides each being formed by two sides of the basal plates, but in the American species, two sides of the triangle are made by the sides of three basal plates and one by the sides of two basals. In the second series there are only three plates, which form the principal part of the calyx, and they partake of the characters of both subradials and radials; one of them bears upon its upper sloping sides, small, radial plates, and is, therefore, a true subradial; the other two bear radial plates upon their upper lateral sides, but each are also truncated in the upper central part for a brachial or arm plate, and, therefore, two plates are both radial and subradial in position. There are, therefore, three small true radial plates, and two large plates, radial in the central part of each, so that the crinoid has only five arms. No radial plate is truncated entirely across the upper face, but in all cases the first brachial or arm-plate rests in a socket with a point of the radial supporting it on each side. The column in all known species is round and the plates of the calyx remarkably thick, especially in the lower half.

There is no other American crinoid having basals that form a triangle, nor having five basals followed by a second series of only three plates, nor having a second series composed of plates, both radial and subradial, in position.

FAMILY, Edriocrinidæ.—Edriocrinus.

Calyx cup-shaped. The base is solid in Edriocrinus, and, therefore, if it ever consisted of more than one plate, the number is unknown, and it constitutes nearly all of the calyx. There are five radials resting in depressions in the base. No regular interradials. An azygous plate, in line with the radials, rests in a basal depression and extends as high as the radials; it is followed by a small plate. But little is known of this family.

FAMILY, uncertain.

The fossil described by Hall under the name of Myrtillocrinus americanus belongs to an undefined genus. The definition of the species is probably incorrect, for in all known palæocrinoidea the rays of the columnar canal notch the basal plates, and this species is figured as having a four-rayed canal and described as having five basals. Probably other specimens will show that it has only four basals, for otherwise it will be quite anomalous, and in either event it is not a Myrtillocrinus.

Nipterocrinus was placed by Wachsmuth in the Icthyocrinidæ without knowing the number of basals in the genus, and Zittel referred it to the Cyathocrinidæ upon equally as good grounds. Until we know whether it has three or five basals, any family reference must be provisional and of little value.

Camarocrinus doubtless belongs to a family Camarocrinidæ, but it is so far removed from other crinoids that it may belong to a distinct order. Ancyrocrinus, Aspidocrinus, Brachiocrinus, Coronocrinus, Cystocrinus and Pachycrinus are genera about which very little is known.

DESCRIPTION OF SOME NEW GENERA AND SPECIES OF ECHINODERMATA FROM THE COAL MEASURES AND SUBCARBONIFEROUS ROCKS OF INDIANA, MISSOURI AND IOWA.

BY S. A. MILLER AND WM. F. E. GURLEY.

(That part of this article describing the fossils on the first four plates was published in the April number of Vol. XIII of the Journal of the Cincinnati Society of Natural History for the year 1890. The whole article, with the ten plates, was published by the authors and distributed in a brochure on the 14th of June, 1890. The edition was limited and it has had a very limited circulation in Indiana. Nearly all of the crinoids are from this State, and on account of the excellence of the work the State Geologist made application to S. A. Miller for leave to reproduce it and for a loan of the plates from which to take electrotypes, and we are happy to state both authors cheerfully united in granting the request. We have been thus enabled to produce a great palæontological work describing and illustrating more than fifty new fossil species of Echinoderms, the types of more than thirty of which were collected in this State, and all of which may be found in our rocks, practically without cost to the survey.—S. S. Gorby.)

Last summer Sidney J. Hare, E. Butts and D. H. Todd collected a lot of very fine crinoids in the Upper Coal Measures, at Kansas City, Missouri, many of which have fallen into the hands of one of the authors of this paper, Mr. Gurley. They are the finest specimens ever found in the Coal Measures, and it is therefore a pleasure to describe them. The stone quarries in the Waverly or Kinderhook group, at Legrand, on the Chicago & Northwestern railroad, in Marshall County, Iowa, contains some layers of yellowish, soft, sandy limestone, bearing the remains of crinoids and other Echinoderms in a remarkably fine state of preservation, and Mr. Gurley visited the locality soon after its discovery and succeeded in obtaining a large collection. He has been an active collector in the rocks of Indiana, Illinois, Iowa and Missouri for many years.

EUPACHYCRINIDÆ, N. FAM.

The genera for which we propose the family name of Eupachycrinidæ, with the genus Eupachycrinus as a type, all belong to the Subcarboniferous system and Coal Measures. The calyx is more or less globular or bowl-shaped, and consists of five basals, five subradials, five primary first radials, concave internally with a broad upper face, from one to three azygous interradials and no regular interradials. There are one or more brachials, and the arms are composed of a double series of interlocking plates, which bear short pinnules. The column is small and round. We include in the family Eupachycrinus, Delocrinus and Ulocrinus.

EUPACHYCRINUS MAGISTER, N. SP.

Plate I, fig. 1, *basal view; fig.* 2, *azygous side view.*

This species is very large; calyx low and broad, somewhat saucer-shaped, bulged a little upon the azygous side, height about half the width, sutures deep, excavation extending about half the thickness of the plates, plates very strongly tuberculated, tubercles conical, elongated and irregular in form and distribution.

The five basal plates are sunk in a cavity on the under side, projecting only half their length beyond the column; even this projection is tubercular; they form in the interior of the calyx a pyramid, which is pierced at the summit by a five-rayed opening connecting with the canal in the center of the column; the points of the rays are rounded. The basal plates are made pentagonal by the truncation made at the points of the rays for the central canal. The diagrammatic views which have been made of the basal plates in this genus are incorrect, in so far as they indicate a pentagonal opening with the angles directed toward the sutures, instead of truncating the plates with the concave depression for the five-rayed opening to the columnar canal. The two basals on the azygous side of the species before us are larger than the others, being nearly as large as the other three.

The subradials are very large, extending into the basal cavity, and curve very gently upward; three are hexagonal, the two longer sides unite with the subradials, the two upper sloping sides, uniting with the first radials, are a little shorter, and the two under sides, uniting with the basals, are very short; two are heptagonal, the one upon the right of the first azygous plate being much larger, and, except the two short sides uniting with the basals, the other sides are of subequal length; the one upon the left has, in addition to the two short sides uniting with the basals, a short side adjoining the second azygous plate. Four of the first radials are pentagonal, twice as wide as high; the upper face is the full width of the plates, and projects over the interior of the calyx, so as to give the appearance of having great thickness when viewed from above. The other first radial, upon the right of the azygous plates, is quadrilateral, except a very slight truncation by the second azygous plate below the depth of the suture. The first radial is separated from the second or brachial piece, on the outer face, by a wide suture, but within a crenated ridge extends from one angle of the plates to another, forming a pentagon, except as separated by the second azygous plate; the ridge has a furrow upon the outer side in the central part of each plate, and within this there is a wide expansion which supports the brachial and arm pieces. The first azygous plate has four sides, rests between the upper sloping sides of two subradials and the long under side of the first radial on the right, with the shorter side abutting upon the second azygous plate. The second azygous plate is hexagonal, curves inward and supports upon its two short inner faces the third and fourth azygous plates side by side. The vault and other parts unknown.

This species would seem to have its nearest affinity with E. tuberculatus, which is described in the Geo. Sur. Ill., vol. II, p. 319. In that species, however, the plates are covered with regularly disposed, narrow, prominent tubercles, the tubercles being arranged in rows, while in this species there is no such arrangement. E. tuberculatus is figured in Geo. Sur. Ill., vol V, plate XXIV, figs. 9a and 9b, and the basal plates are proportionally larger, and the under sides of the subradials longer, than they are in the species under consideration, beside all the plates have a different shape, and the sutures are not excavated so deep as in the species before us.

Found in the Upper Coal Measures of Kansas City, Missouri, and now in the collection of William F. E. Gurley.

EUPACHYCRINUS SPHÆRALIS, N. SP.

Plate I, fig. 3, basal view; fig. 4, azygous side view.

This species is large and constricted at the top of the first radials; calyx somewhat like a widened or inflated sphere, width two-thirds greater than height, sutures distinct but not so deeply excavated as in E. magister; plates irregularly tuberculated, but tubercles not half as large as in E. magister.

Basal plates are sunk in a cavity on the under side, and project less than half their width beyond the column; subradials, large, extend into the basal cavity and curve upward half the height of the calyx; three are hexagonal and two heptagonal; first radials pentagonal, though the one on the right of the azygous area has a very short truncated side abutting upon the azygous plate; second primary radial, or first brachial piece, smaller than the first and of similar form, except inverted, and bears upon its upper sloping sides the free arms; the one opposite the azygous side bears two arms, each of which has a single plate followed by a double series of interlocking ones; the others support four arms each; the upper sloping sides bear pentagonal plates, similar in form to the second radials, which are followed with a single plate that, in its turn, bears a double series of interlocking ones.

There are fourteen large, long arms, composed of a double series of interlocking pieces, rounded externally, and flattened upon the sides so that, in an accumbent position, they close somewhat like the arms of an Ichthyocrinus; the arms in our specimens are spread out and the extremities are not preserved; pinnules numerous, but not very long; column round, and rather small for such a large crinoid.

This species has its nearest affinity with E. verrucosus, described in the Trans. Chi. Acad. Sci., Vol. 1, p. 117, and re-described and figured in the Report on the Palæontology of Eastern Nebraska, page 150.

Found in the Upper Coal Measures, at Kansas City, Mo., and now in in the collection of Wm. F. E. Gurley.

ULOCRINUS, N. GEN.

(*Ety., oulos, solid, substantial; krinon, lily.*)

This genus has a more or less globular or pyramidal calyx, and is related to Eupachycrinus and Delocrinus. There are five basals, forming a slightly convex pentagonal disc, or a low cup; they are of the same size and usually anchylosed; on the exterior of the cup the columnar extention is round, depressed below the surface of the plates and radiately furrowed like the articulating faces of the plates of many crinoid columns; on the interior, a star-like, columnar opening truncates the basal plates with the points of the five rays, between which there are radiating furrows for the attachment of the ligaments. By this arrangement the points of the basal plates are disconnected only by the star-like perforation.

There are five subradials, each one of which may be as large or larger than the five united basals, all regularly alternate with the basals and have the same form, except that one may be truncated by an azygous plate.

The first primary radials are pentagonal and regularly alternate with the subradials, except as interrupted by an azygous plate, they are much wider than high, the upper face is the full width of the plate and projects over the interior of the calyx so as to make a broad articulating face for the first brachial piece; the internal side of the first radial is concave, on the upper face of the plates a furrow extends from one angle of the plates to another, on the inner side of which there is a crenulated ridge for the articulating brachial piece, and an interior central depression and slight concavity at the central internal margin.

There are no regular interradials. A single large quadrangular azygous interradial rests obliquely between two subradials and two primary radials, and form part of the wall of the calyx; upon an angle of this, at the top of the calyx, a small plate intervenes and projects slightly above the first radials. The column is round. Other parts unknown, though very thick, heavy plates, bearing a spine like the first brachial plate of a Delocrinus are found associated, and believed to belong to this genus.

The cup formed by the basal plates distinguishes this genus from Eupachycrinus and Delocrinus, both of which have a concave base and an interior pyramid formed by the basals; the second azygous plate does not truncate a subradial, and forms no part of the wall of the calyx in this genus as it does in Eupachycrinus. It is probably as nearly related to Delocrinus as it is to Eupachycrinus, though at first view it would seem to be more nearly related to the latter. Type U. buttsi.

Ulocrinus buttsi, n. sp.

Plate I., fig. 5, azygous side view; fig. 6, basal view.

The calyx of this species is pyramidal or has the form of half an ellipse, elongated. The plates are moderately thick and convex externally so as throw the sutures into wave-like depressions; the sutures are distinct, but the plates are not deeply beveled as is common in many species of Eupachycrinus; the surface was, probably, strongly granulous, as the better preserved plates are rough, though evidently slightly worn.

The basal plates are large and form a cup about half as high as wide; the perforation for the columnar canal is pentagonal and star-like; the subradials are very large and longer than wide, which produces the great length or pyramidal form of the calyx; four of the plates are hexagonal and one heptagonal; four of the first radials are pentagonal, wider than long and truncated above the full width of the plates; the one on the right of the azygous side is possibly hexagonal, as one side may be slightly truncated by the second azygous plate; the upper face of the first radials bears a furrow extending from one angle of the plates to another, behind which there is a narrow, crenulated ridge, on which the second radials or brachial pieces articulated. The first azygous plate is irregularly quadrangular and rests obliquely in a notch on the top of a subradial and below the under sloping side of the first radial on the right, but it does not reach the second subradial. The second azygous plate is injured in our specimen, but it appears to have slightly truncated one angle of the first azygous plate, and the two abutting first radials at the top of the calyx

Found in the Upper Coal Measures, at Kansas City, Mo., and now in the collection of Wm. F. E. Gurley. The specific name is in honor of Mr. E. Butts, of Kansas City, who has done a great deal to make known the natural history of that vicinity.

ULOCRINUS KANSASENSIS, N. SP.

(*Plate I, Fig.* 7, *azygous side view; Fig.* 8, *outline view regular side; Fig.* 9, *top view of calyx to show the prolongation of the first radials and contracted opening of the calyx; Fig.* 10, *basal view*).

The calyx of this species is somewhat half-globular in form, though the height is more than two-thirds the width at the top; the plates are moderately thick and quite convex externally, so as to place the sutures in wave-like depressions quite as deep as they are in U. buttsi; sutures distinct, but the plates are not beveled; surface granulous.

The basals form an equal-sided convex pentagon, with a central depression for the star-shaped columnal canal; the subradials are each about the size of the united basals, a little wider than high, all pentagonal and nearly equal-sided, except the hexagonal plate supporting the lower face of the azygous plate. The first radials are pentagonal, except the one on the left of the azygous plates, which becomes hexagonal by the very slight truncation made by the second azygous plate; they are twice as wide as high; the upper face is the full width of the plate, and extends internally nearly one-third the diameter of the calyx; in the specimen described, the width of the calyx is $1\frac{3}{10}$ inches, and the projection of these plates $\frac{4}{10}$ inch, leaving the opening at the top of the calyx only one-half an inch, while the great concavity on the inner side of these plates will give an internal diameter of the calyx immediately below the top of the first radial of nearly an inch; the upper surface is broader than it is in E. buttsi, but the markings for the articulating brachials seem to be about the same.

The azygous plate forms part of the calyx, is quadrangular, nearly as large as a first radial, rests obliquely between two subradials and the under sloping side of the right first radial and a second under sloping side of the left first radial; the upper angle extends about as high as the upper face of the radials, and is very slightly, if at all, truncated by an angle of the small second azygous plate.

This species is remarkable for the great over-lapping or interior projection of the first radials, and in this respect exceeds all known species of Delocrinus and Eupachycrinus. No part above the first radials is known, but some equally remarkably thick brachial plates each bearing a very large spine, occurring at Rock Creek, in Jefferson County, Kansas, appear to belong to this species.

Found in the Upper Coal Measures at Kansas City, Mo., and now in the collection of Wm. F. E. Gurley.

DELOCRINUS, N. GEN.

Ety., delos. manifest, clear; krinon, lily.

The species belonging to this genus are usually robust, calyx basin-shaped, arms broad, composed of a double series of interlocking pieces joining neatly with each other, column round, plates thick, and surface smooth or finely granulous, not sculptured; basals five, occupying a concavity on the under side, and more or less hidden by the column, but forming a little cone in the interior of the calyx; subradials pentagonal and hexagonal, larger than the basals, the lower part inflexed by the depression of the base to meet the basal plates, the middle regularly arched, and the upper part forming a more or less acute angle between the under sloping sides of the first radials; first radials wider than high, pentagonal, upper face truncated the entire width of the plates and separated from the second radial or brachial plate on the outer face by a strong suture, but immediately within a straight crenated ridge extends from one outer angle of the plates to the other, on the upper face of the plates, which is furrowed upon each side so as to form a toothed hinge upon which the second radial or first brachial articulates; behind this hinge, in the middle part of each plate, there is a depression or socket for the reception of a tooth-like projection. On the other side of the second radial or brachial, a dart-shaped furrow also extends on the upper side along the line of union of plates, commencing just within the angle arising from the union of the crenulated ridges and extending to the interior of the cup which receives a corresponding projection from the second radials; second radials or brachials pentagonal, produced externally in a more or less strongly developed spine, and bearing upon the upper or inner sloping sides the free arms, the first one or two plates of which are single, but above these composed of a double series of interlocking plates; when the arms are closed the pinnules are within, and the body is compact something like an Encrinus; there are no regular inter-radials; a single azygous interradial rests upon the truncated upper end of a subradial, between two first radials, and extends upward between the second radials or brachial plates. It is truncated at the upper end and followed by a single piece, beyond which the connection with the vault or proboscis is unknown. Type D. hemisphericus.

The species upon which this genus is founded was first defined by Shumard, under the name of Poteriocrinus hemisphericus, in 1858, in the Transactions of the St. Louis Academy of Science, vol. I, p. 221; Meek, in 1872, under the name of Scaphiocrinus (?) hemisphericus, Shumard, in the Report on the Palæontology of Eastern Nebraska, p. 147, pl. V, fig. 1a, 1b, and pl. VII, fig. 1a, b, c, redefined and illustrated Cyathocrinus inflexus of Geinitz, which is a distinct species as pointed out by Geinitz, though congeneric. In 1873, under the name of Scaphiocrinus (?) hemisphericus, Shumard, in Geo. Sur. Ill., vol. V, p. 561, pl. XXIV, fig. 5, Meek, probably, correctly identified and illustrated this species.

In 1880, in the Proceedings U. S. National Museum, vol. II, p. 257, White described a species under the name of Erisocrinus planus, which was redescribed and figured in Hayden's Twelfth Ann. Rep. Geo. Sur. Terr., p. 127, pl. XXXV, figs. 5a and 5b, under the name of Erisocrinus (Ceriocrinus) planus. Ceriocrinus being proposed and described as a subgenus of Erisocrinus and a comparison made with the Poteriocrinus hemisphericus of Shumard and Cyathocrinus inflexus of Geinitz. Ceriocrinus was preoccupied in the Echinodermata, by Koenig, and hence the use of the word by White is not allowable. The genus here under consideration and founded upon the Poteriocrinus hemisphericus of Shumard is not a subgenus of Erisocrinus, nor does it have any near affinity with it, probably not even family affinity, as will be apparent on the inspection of the species of Erisocrinus which have been illustrated. Its nearest generic relations are with Eupachycrinus or Ulocrinus. The Erisocrinus planus of White may not be congeneric with this species, because the small azygous plate does not rest on a subradial, but stands upon two radials and projects upward between two second radials. Only the calyx is known, and it may be that other parts, when found, will distinguish it from this genus, or possibly unite it with Erisocrinus. We are inclined to believe that Wachsmuth & Springer were not very careful in their examination of these forms, for when referring to the two species, hemisphericus and planus, near the top of the page 254, pt. 3, Palæocrinoidea, they are made to say, "We, therefore, can not agree with White in considering the two forms generically identical, and much less specifically," and yet, near the bottom of the same page they refer both hemisphericus and planus to White's proposed genus Ceriocrinus, and under the name of Ceriocrinus hemisphericus they refer with approval to Meek's identification in the Report on the Palæontology of Eastern Nebraska, p. 147, which is simply a reproduction of the inflexus of Geinitz, which is a distinct species that they recognize on the same page.

In the North American Geology and Palæonthology S. A. Miller con demned Ceriocrinus of White on the ground that the name was preoccupied, and referred the hemisphericus to Eupachycrinus, the nearest allied genus then described.

This genus, so far as known, is confined to the Coal Measures of the Western States and Territories. We refer the following species to it:

Delocrinus craigi (Eupachycrinus craigi), Meek and Worthen, Geo. Sur. Ill., Vol. VI, p. 527, pl. XXXII, fig. 1, and 1a.

Delocrinus fayettensis (Eupachycrinus fayettensis), Worthen, Geo. Sur. Ill., Vol. V, p. 565, pl. XXIV, figs. 10, 10a.

Delocrinus hemisphericus (Poteriocrinus hemisphericus), Shumard, Trans. St. Louis Acad. Sci., Vol. I, p. 221. Type of the genus.

Delocrinus inflexus (Cyathocrinus inflexus), Geinitz, Carb. und Dyas in Nebraska, p. 62, pl. IV, figs. 20a, b, c, and doubtless the spines and some of the plates and fragments of columns figured on the same page under the name of Actinocrinus sp. The spines figured by Meek in the Report on the Palæontology of Eastern Nebraska, pl. V, figs. 2a, 2b and 2c, under the name of Zeacrinus mucrospinus probably belong to this species, while the form fig. 1 called Scaphiocrinus (?) hemisphericus may be distinct. Delocrinus missouriensis n. sp. And very doubtfully the Erisocrinus planus of White above referred to.

Delocrinus hemisphericus, Shumard.

Plate II, Fig. 8, *side view, showing azygous plate and first brachial, with spine; Fig.* 9, *basal view of same; Fig.* 10, *inner side of brachial spine magnified two diameters.*

Shumard defined this species as follows:

"The *body* of this species is subhemispherical, concave below, and the surface finely granulose.

"The *base* is very deeply concave, pentagonal and completely concealed from view when the column remains attached to the cup. The five pieces of which it is composed are of a rhombic shape, longer than wide, and the interior edges nearly double the length of the exterior ones.

"The *columnar facet* is circular, crenulated on the border; the central perforation rather large and pentalobate. In the interior of the calyx the base forms an elevated conical protuberance.

"The *subradial* pieces are thick and longitudinally recurved; four of them are pentagonal, a little longer than wide, their superior edges gently arched and slightly longer than the infero-lateral edges; the basal edges are very short. The fifth subradial is hexagonal, its superior angle being truncated to support an anal piece.

"The *first radial pieces* are pentagonal, very massive, and as wide again as long. The inferior edges are slightly concave and of equal length in three of the pieces, but on the anal side they are unequal. The superior edge is nearly straight and rounded. The articular facet is very broad, nearly horizontal, and furnished with a prominent transverse ridge, which is situated nearest the external margin. Exterior to this is a small ridge which coalesces with the main one before reaching the extremity of the pieces. Both ridges are strongly crenulated.

"*Anal pieces.* Of these pieces only one remains in the specimen before us. It is rather small, elongated hexagonal, and is wedged in between two of the first radials, above which it projects about half its length.

"The secondary radials, vault, arms and column are unknown.

"*Dimensions.* Height of calyx, .30; width, .90; height of first radial pieces, .26; width of same, .42."

His specimens were from Hinkston Creek, Boone County, and on the Missouri River, near Lexington, while our specimens are from Kansas City in the same vicinity. His definition is complete, as far as it goes, and we may add only that which our specimens disclose in addition.

The column is round and composed of alternately thicker and thinner plates radiately furrowed near the outer circumference of the articulating faces; the second radial or brachial articulates upon the crenated ridge on the top of the first radial, bears a tooth-like process that enters the socket in the middle of the posterior part of the first radial, and lateral processes that fill the furrows at the united joints of the first radials, and bears a strong spine, externally, that is directed upward at an angle of about forty-five degrees; the plates bear upon their upper inner sides the free arms; arms, ten; the first plate articulates upon the serrated edge of the second radial; the next plate is wide and thin, and above this the arm consists of a double series of thick interlocking plates that make coarse, wide arms, depressed convex externally, and flattened upon the sides almost as if cut by a knife, so as to close up tight like an Encrinus; the first azygous plate is truncated and subquadrate upon the upper face, which is serrated near the outer margin for the articulation of the second plate; beyond this the vault is unknown.

Delocrinus missouriensis, n. sp.

Plate II, fig. 11, *side view showing column ; fig* 12, *basal view ; fig.* 13, *azygous side view.*

This species may be distinguished at first view from D. hemisphericus by the lower calyx and more angular outline, and the top of the calyx, when viewed from below, presents a pentangular outline; the basals extend slightly beyond the column, the subradials in the median part are sharply convex, as distinguished from the gently arching plates in D. hemisphericus and do not extend as high proportionally as they do in the latter species, which reduces the height of the calyx. First radials regularly convex in the middle part, but depressed medially toward the upper face of the plates, which produces the pentangular outline when viewed from below. The second radials or brachials, while exposing a very wide suture, are not quite as thick and do not stand as upright as they do in D. hemisphericus and have a more slender spine. The azygous plate is the same as in D. hemisphericus. The column is not as regular in the alternate arrangement of the thicker and thinner plates as in D. hemisphericus, the larger plates project far beyond the thinner ones and sometimes there are two or more thinner plates between the thicker ones.

Found in the Upper Coal Measures in Kansas City, Missouri, and now in the collection of Wm. F. E. Gurley.

ÆSIOCRINUS, N. GEN.

Ety., aisios, auspicious, coming at good time; krinon, lily.

Column pentagonal, calyx bowl-shaped, plates smooth or finely granulous, basals five, forming a pentagonal flattened or slightly concave disc, subradials rather large, four hexagonal and one heptagonal, and curving upward so as to reach half the height of the calyx. First radials, five, pentagonal, wider than high and truncated the entire width for the brachials, one or more brachials in each ray supporting strong arms composed of a single series of plates. Arms, ten, bearing pinnules. No regular interradials. A single azygous interradial rests upon the truncated upper end of a subradial, between two first radials, and is followed by two plates that connect with the base of the proboscis. Proboscis, long, composed of four series of gradually tapering plates bearing numerous transverse respiratory fissures or slits on the sides of the plates.

The calyx of this genus bears some resemblance to that of an Erisocrinus, but the pentagonal column and azygous plate distinguish it. The azygous plate truncates a subradial as in Delocrinus, but otherwise there is no resemblance between the two genera. The long, flowing arms composed of single plates and the remarkably large and peculiarly constructed proboscis characterize this genus and distinguish it from all others. Its family affinities would seem to be with the Poteriocrinidæ, but probably a new family should be defined for its reception.

ÆSIOCRINUS MAGNIFICUS, N. SP.

Plate II, Fig. 1, natural size of a specimen as it lies on a slab; Fig. 2, a free proboscis nearly entire and only slightly twisted; Fig. 3, portion of same magnified 2½ diameters to show more distinctly the respiratory openings; Fig. 4, an abnormal branching proboscis; Fig. 5, sectional end view of proboscis.

Calyx deep, bowl-shaped, surface of plates finely granulous; sutures distinct but not beveled; basals forming a pentagonal flattened disc having an outline about twice the diameter of the column; subradials rather large, four hexagonal, one heptagonal, bending abruptly upward from the union with the basals, the upper angle extending high between the first radials so as to make the upper sloping sides of the hexagonal plates much the longer; first radials larger than the subradials, about one-half wider than high, all pentagonal with lateral and inferior sides of equal length and upper truncated sides extending to the fullest width of the plates; first brachial plates wide, short, rounded, separated exteriorly from the first radials by a beveled suture; second brachials wide, short, with long upper sloping sides for the articulation of the large arm plates; arms ten, long, round exteriorly and composed of short cuneiform plates;

pinnules short and rather thick. Proboscis remarkably large, long and composed of four series of gradually tapering convex, tuberculated plates, somewhat similar in appearance to four round tapering columns placed together, giving transversely a subquadrate outline; there is no azygous or anal opening in the proboscis, but there are numerous transverse, respiratory fissures or slits in the longitudinal depressions; these slits exist on both sides of every plate of the proboscis from the second brachials to the very top; some specimens of the proboscis have one or more intercalated plates near the lower end, and all are more or less twisted. There is a bifurcated proboscis in the collection which has five series of plates below the bifurcation, and three intercalated series at the bifurcation, so that each branch has four series, which we have illustrated. It is an abnormal specimen that may have resulted from an injury. The column is small, pentagonal, tuberculated and bore cirrhi to a greater or less extent.

This species was collected in the Upper Coal Measures, at Kansas City, and the specimens are in the collection of Wm. F. E. Gurley, of Danville, Illinois.

ÆSIOCRINUS HARII, N. SP.

Plate III, fig. 1, natural size as it lies upon a slab.

This species is distinguished from A. magnificus by having proportionally a much smaller and a smooth proboscis. The calyx is bowl-shaped; column pentagonal; basals of moderate size; subradials convex and extending half the height of the calyx; first radials wider than high; first and second brachials and arms as in A. magnificus, but proportionally smaller. The proboscis is much smaller in proportion to the size of the calyx than it is in A. magnificus, and the exterior of the plates is smooth, though the respiratory fissures in the two species are alike. This species is thus founded upon the surface character of the proboscis, and the proportionally larger calyx when compared with other parts of the body and arms.

These Kansas City fossils were collected in blue clay, where they were remarkably well preserved; but some specimens were injured by the collectors, who undertook to wash them when no water should have been applied. Many of the specimens were found with the heads downward and the arms spread out, leaving the base of the calyx upward, with the strong proboscis pressed to one side, as shown in the illustration of this species.

From the Upper Coal Measures of Kansas City, and now in the collection of William F. E. Gurley. The specific name is in honor of Sidney J. Hare.

HYDREIONOCRINUS PENTAGONUS, N. SP.

Plate II, fig. 6, view of azygous side, showing height of calyx and upper truncated face for second radials; fig. 7, basal view.

Calyx large pentagonal and exceedingly depressed to the top of the first radials; plates very thick and sutures well defined; basals rather large and forming an octagonal ring around the end of the column, against the faces of which the subradials and three of the radials rest; subradials small, three triangular, one quadrangular and the other pentagonal, by reason of supporting the first azygous plate; they are slightly convex, and lie in furrows made by the angular convexity made by the first radials; first radials about twice as wide as high, the height not much exceeding the thickness of the plates; the plates are hexagonal, highly convex, depressed toward the sutures, and truncated upon the outer faces, so as to give the calyx a pentagonal outline; the depressions at the sutures appear as furrows in the pentagonal outline of the calyx; first azygous plate quadrangular, narrow, resting upon the upper sloping side of a subradial and forming the bottom of the furrow between two first radials; second azygous plate heptagonal, slightly truncating two first radials; column round.

Second radials and succeeding parts above unknown, and it is therefore possible that this species is a Zeacrinus, but from the characters given the inference is, it possessed the ventral sac of an Hydreionocrinus, beside the latter genus had, so far as known, its greater development in the Upper Coal Measures, while the former is more characteristic of the upper part of the Subcarboniferous or Kaskaskia Group. It is unnecessary to compare this with any species heretofore defined, because it is easily recognized by its strongly marked characters.

Collected in the Upper Coal Measures at Kansas City, and now in the cabinet of Wm. F. E. Gurley, of Danville, Illinois.

ONYCHOCRINUS ULRICHI, N. SP.

Plate III, fig. 2, azygous side; fig. 3, symmetrical side, natural size.

Calyx depressed, saucer-shaped; plates finely granulous, sutures distinct; basals three, extending slightly beyond the column; four of the subradials pentagonal, the one opposite the azygous side being the larger one and all sharply pointed at the upper angle; the other one is hexagonal with an upper concave articulating facet for the first azygous plate; primary radials five in each ray, very gradually decreasing in size upward and becoming more and more sharply rounded; each one is wider than high and the sutures are transverse, with the exception of a slight concave central, exterior depression; the fifth plate is angular in the central part of the upper face and supports the two series of brachials; the brachials and arms are very short and thick, and the sutures between the plates become more and more sinuous toward the extremities; the first arm is given off at about the fourth brachial, and above this there are twelve or more short, branching, curving arms that form a cluster at the end of each ray.

The first regular interradial is large and octagonal; it is followed by three plates and these by five, and above they are smaller and more numerous; four interbrachial pieces are visible in our specimen, and there are probably more; the azygous plates are small, short, and sutures sinuous.

Found in Keokuk Group, at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley. The specific name is in honor of Prof. E. O. Ulrich, of Newport, Ky.

AGARICOCRINUS SPLENDENS, N. SP.

Plate IV, fig. 1, *side view with arms; fig.* 2, *basal view of same.*

This species is of medium or rather under medium size; base concave; surface granulous; basals small; first radials small; second radials quadrangular, wider than long; third radials pentagonal, wider than high, and supporting upon each of the upper sloping sides a thin brachial plate, which is followed by another thin plate, having two upper slightly sloping sides which support the regular interlocking series of the arm plates; arms twelve, three in each ray adjoining the azygous side, and two in each of the other three rays; they are a little longer than the greatest diameter of the calyx, rather small and taper to a point; pinnules fine; regular interradial areas narrow, the first plate resting between the second radials, which is followed by two smaller ones situate between the third radials and the first brachials; azygous area having one plate followed by three of nearly the same size, which give breadth to the area between the third radials and the brachial plates; the column is round and composed of alternately thicker and thinner plates. Our specimens do not show the vault.

This is a beautiful little species, quite different from any heretofore described, and occurs in the Keokuk Group, at Crawfordsville, Ind. It is in the collection of Wm. F. E. Gurley.

BATOCRINUS MARINUS, N. SP.

Plate IV, fig. 3, *side and basal view; fig.* 4, *outline view of plates on azygous side.*

Species about the average size; calyx expanded at the arm bases so as to be wider than high, and to make the openings through the vault from the arm furrows at right angles to the calyx, surface of the plates flattened and finely granulous; basals three, upright and forming a circle which appears as if it were the enlarged end of the column; first radials wider and larger than the second and third together, three heptagonal and two hexagonal; the upper face is truncated for the second radial, and the upper sloping sides support the first interradials; second radials quadrangular, a little wider than high; third radials wider than the second but not longer, pentagonal or hexagonal, the lower lateral sides spreading so as to give the greatest width at the angles made with the upper sloping sides; the upper sloping sides support the secondary radials; secondary radials 2x10, wider than long, somewhat variable in size and shape, the second one bearing upon its upper sloping sides a single tertiary radial; the tertiary radials are succeeded by a double series of interlocking arm plates; arms twenty, rather small, slender, gradually tapering and composed of a double series of plates, alternately interlocking; in our specimens they are coiled together on the vault around the base of the proboscis; pinnules very numerous. Regular interradials five, the first one polygonal, about as large as a first radial and nearly as large as the other four; the first one is followed by two plates and these by two which are between the second secondary radials and the upper sloping sides of the tertiary radials; there is one intersecondary radial in each area; azygous interradials nine, the first one in line with the first radials and of the same size; this is followed by three smaller ones, and these again by three, and these by two which fit between the under sloping sides of the tertiary radials; the proboscis is broken off in our specimen at the top of the folded arms.

Found in the Keokuk Group at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

Batocrinus jucundus, n. sp.

Plate IV, fig. 5, azygous side with arms; fig. 6, symmetrical view with arms removed, showing proboscis.

Species rather small; calyx globose, nearly as wide as high, height of calyx a little more than height of dome to the base of the proboscis; arm bases very slightly projecting, and arm openings projected upward; surface of the plates smooth or finely granulous, more or less convex or tumid; basals three, short, upright, and forming a pentagonal ring around the column; first primary radials much wider and larger than the second and third together; on some specimens there is an elongated, transverse tubercle on each one, the upper face is broadly truncated for the interior face of the succeeding radial, and the upper sloping sides support the first interradials; second primary radials quadrangular, one-half wider than long; third primary radials wider and larger than the second, pentagonal or hexagonal, the lower lateral sides spreading so as to give the greatest width at the middle part of the plate or at the angles made with the upper sloping sides; the upper sloping sides support the secondary radials; secondary radials 2x10, wider than long, the upper the larger, but both of them variable in size and shape; six of them have upper sloping sides for tertiary radials, while four of them bear only a single tertiary radial. Each second secondary radial in the ray opposite the azygous side bears a single arm, and one of the lateral secondary radials on each side bears a single arm; there are, therefore, only sixteen arms; a single plate follows each tertiary radial, and above this the arm is constructed of two series of small plates alternately arranged; the arms are rounded on the outer side, gradually tapering, and bear numerous long pinnules, composed of comparatively long pieces; regular interradials, in some areas two and in others three, the first one polygonal and larger than any other plate above he first primary radials; when it is followed by two interradials they are together no larger than a single secondary interradial; azygous interradials eight or nine, the first rests between the upper sloping sides of two basal plates and is in line with the first radials; it is followed by three plates in the second series, and in one specimen three plates in the third series and in another four; these are followed by a single plate projecting an angle up between the under sloping sides of tertiary radials; the vault and proboscis are constructed of highly tumid polygonal plates; the proboscis extends as far as or beyond the arms; column round.

This is a handsome little species, distinguished by its sixteen arms and the structure of the calyx from all others.

Found in the Keokuk Group at Crawfordsville, Indiana, and now in the collection of William F. E. Gurley.

Dichocrinus cinctus, n. sp.

Plate IV, fig. 10, *symmetrical side view; fig.* 11, *azygous side, showing vault and valvular opening; fig.* 12, *summit view.*

Calyx obconoidal, nearly twice as high as wide, somewhat truncated at the arm bases, except upon the azygous side, surface of the plates bearing a collection of fine longitudinal lines from the rim at the base, over the central part of the first radials, to the first rim plates, with fine transverse lines between, especially near the top of the calyx; sutures not impressed, and the transverse and longitudinal lines cross without interruption; the band or rim at the base suggests the specific name. The two basals form a little cup, the height of which is equal to the greatest diameter; they are contracted above the base so as to leave a small, smooth, half-cylindrical rim or band at the bottom of the cup; the first radials are about twice as long as wide, very gradually increase in width to the upper truncated end, which bears a concave facet, a little more than one-third the width of the plate, for the attachment of the second radial or first brachial piece; second radial thin, rounded; the third radial a little thicker, rounded, and bearing upon its upper sloping sides the free arms; arms ten, long, rounded externally, composed of a single series of thin plates, bearing long, strong pinnules closely packed together.

Regular interradials forming part of the vault, and standing but very little above the upper truncated edge of the first radials; first azygous interradial as large as the first radials, inflected toward the vault, and bearing fine longitudinal lines in the middle and lower central part, and transverse lines on each side of these on the upper part; the succeeding plates cover a moderately convex ridge, expanded a little above the other part of the vault, which extends to the side of a central nipple occupying the summit of the vault, and at the junction there is a valvular opening, but it is not connected with the central elevation; this nipple-like elevation is covered with very small polygonal plates, and from the lower part of it five ambulacral ridges radiate to the second and third radials, which ridges are covered with minute polygonal plates. The column is round and composed of thin plates with sharp projecting edges.

Found in the Kinderhook or Waverly Group, at LeGrand, Iowa, and now in the collection of Wm. F. E. Gurley.

Poteriocrinus granilineus, n. sp.

Plate IV, fig. 7, natural size.

Calyx low, basin-shaped; sutures well defined; basals small and hidden by the column; subradials small, hexagonal, except one on the azygous side, which is truncated at the top and heptagonal; first radials wide, short, pentagonal, and truncated on top, where they have their greatest width; second radials quadrangular, short, wider than the first, and having the greatest width at the upper truncated surface; third radials wider than the second, pentagonal, very short, with steep upper sloping sides, which are slightly curved to receive the free arms; arms short, composed of short cuneiform plates, so strongly arched in the middle as to form a subangular ridge down the back of all the rays, on which the granules are so united as to form a keel; all the arms preserved in our specimen (six in number) bifurcate on the sixth plate, and above this the bifurcations are irregular, one of them bifurcating on the fourth plate, and others do not seem to bifurcate at all; the arms are flattened so as to fit closely together as in Zeacrinus; pinnules not observed; the first azygous plate is inserted obliquely between a subradial and the upper sloping side of a first radial, with the truncated lower end resting against another subradial; this plate is pentagonal; the second azygous plate rests upon the first above-mentioned subradial, and between the radials on the left and upper sloping side of the first azygous plate on the right; the higher azygous plates are not shown in our specimen; the column is rather small and obscurely pentagonal near the head.

The surface of the plates of body and arms is strongly granulated, and this, with the angularity of the arms and the union of the granules forming a sharp ridge or keel down all the rays, strongly characterize this species, and suggests the specific name. It probably belongs to that branch of the genus Poteriocrinus for which Wachsmuth suggested the name Pachylocrinus.

Found in the Keokuk Group at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

POTERIOCRINUS CRAWFORDSVILLENSIS, N. SP.

Plate IV, fig. 8, natural size.

Species large, robust; calyx obconoidal, expanding very gradually from the large column, longer than wide, and composed of smooth, rounded plates with well-defined sutures; basals large, widening but little upward, pentagonal, about as wide as high; subradials longer than wide, expanding but little upward; those shown in our specimen hexagonal, the two on the azygous side probably heptagonal; radials pentagonal, very little wider than high, the articulating surface occupying the entire width of the plates; the second radial or brachial plate in the ray opposite the azygous side is pentagonal, about as high as wide, rounded, and supports upon its two upper sloping sides free arms, one of which bifurcates on the third plate above, and the other does not divide; the arms are robust, long, very slowly tapering, rounded, and composed of thick cuneiform plates; column large, round, composed of thicker and thinner plates, the articulating faces of which are marked by radiating furrows, which show the serrated edges. Proboscis and other parts unknown.

This species belongs to that branch of Poteriocrinus for which Wachsmuth proposed the subgeneric name of Scytalocrinus. Its characters are very strongly marked, and it resembles P. missouriensis, from the St. Louis Group, about as much as it does any other species in the genus.

It was found in the Keokuk Group, at Crawfordsville, Indiana, and belongs to the collection of Wm. F. E. Gurley.

POTERIOCRINUS VERUS, N. SP.

Plate IV., fig. 9, natural size.

Specimens medium size; calyx obconoidal, expanding very gradually, as long as wide, and composed of smooth rounded plates; sutures distinct; basals pentagonal, standing upright, nearly as high as wide; subradials hexagonal on the symmetrical side, about one-half larger than the basals and a little longer than wide; radials pentagonal, wider than high, a little smaller than the subradials, convex, truncated the entire width of the plates with suture gaping; there are five brachials in two rays and seven in the other, in our specimen before a bifurcation is reached. These plates are nearly as long as wide, round externally, and very slightly constricted, and the sutures are gaping; the last one has very steep, upper-sloping sides for the arms; arms ten, long, composed of very long constricted plates with slanting, gaping sutures; proboscis long. Our specimen shows five subquadrate plates where the arms are broken away, indicating that the proboscis extended nearly or quite to the ends of the arms. Column round, and articulating faces of the plates radiately furrowed.

Found at Crawfordsville, Indiana, in the Keokuk Group, and now in the collection of Wm. F. E. Gurley.

SCAPHIOCRINUS MANUS, N. SP.

Plate IV., fig. 13, *azygous side, natural size.*

General form of calyx and arms having a fancied resemblance to a hand; calyx cup-shaped, height about the half the diameter at the top, plates convex and sunken at the angles of the sutures; basals hidden within a shallow depression surrounding the end of the column; subradials hexagonal, except one on the azygous side which is truncated at the top and heptagonal; they are larger than the basals, and about half as large as the first radials; first radials pentagonal, one-half wider than high, convex at the upper part, truncated the entire width, and separated from the brachials externally by a wider suture. There is only a single brachial in each ray, and it is rather larger than a first radial, pentagonal, constricted, angular and supports on its upper sloping sides the free arms; the two arms on the left of the azygous plate and the one on the right bifucate on the eighth plate, and the second arm to the right of the azygous plates bifurcates on the tenth plate; the plates are very slightly wedge-shaped, and have their thickest margins produced into nodes, the alternate arrangement of which gives the arms a rough aspect; pinnules coarse, making the head appear full and dense. The first azygous plate rests between the first two radials, the under side of the first radial on the right, and the second and third azygous plates; the second azygous plate is of the same size as the first, rests on the truncated end of a subradial, and abuts upon a first radial and brachial on the left, the first and third azygous plates on the right and another azygous plate at the top; the third azygous plate is a little smaller, and abuts a brachial on the right. Column and vault unknown.

Found in the Keokuk Group, at Crawfordsville, Indiana, and now in the collection of Wm. F. E. Gurley.

ACTINOCRINUS GRANDIS, N. SP.

Plate V, fig. 1, *symmetrical side; plate VI, fig.* 1, *azygous side.*

This is a very large species and proportionally very long; the plates are thick, angular, and deeply sculptured; our specimen has a length of $2\frac{3}{4}$ inches, diameter at the top of the third primary radial $1\frac{9}{10}$ inches, at the top of the basals $\frac{9}{10}$ inch, height of basals $\frac{1}{2}$ inch; the sutures are depressed, and while the ornamentation resembles that on Strotocrinus regalis, the ridges are stronger and sculpturing deeper; the radial ridges are high, so that a transverse section above the middle of the first radials is pentagonal; there are deep depressions between the arms, giving a pentagonal outline when seen from above, and this is strongly marked because the vault rises but very little above the radial ridges extending to the bases of the arms.

Basals three, pentagonal, standing nearly upright, and forming a deep bowl-shaped cup having a length more than half its diameter; first primary radials very large, longer than wide, three hexagonal and two heptagonal; second primary radials about as wide as long, hexagonal; third primary radials heptagonal, wider than long, and supporting upon the two upper sloping sides the secondary radials; secondary radials forming the basal support of the arm-like projections, hexagonal, and supporting upon their upper sloping sides tertiary radials; first regular interradial hexagonal, about the size of second primary radials, supported between the upper sloping sides of the first primary radials and the under sloping sides of the second primary radials. This is followed by two hexagonal plates nearly as large as the third primary radials, and these by three plates, and above the plates graduate through a depressed and sunken area into the plates of the vault; first azygous plate about as large as a primary radial, hexagonal, and resting upon two basal plates; it is followed by two hexagonal plates about as large as the second primary radials, and these by three plates nearly as large as the third primary radials, and these by four plates, and above the plates graduate through a depressed and sunken area to the vault; the vault is covered with small, tumid, polygonal plates; the arm openings are directed upward almost at right angles to the radial ridges from the central area of the vault.

Found in the Keokuk Group, in Washington County, Indiana, and now in the collection of William F. E. Gurley.

TAXOCRINUS SUBOVATUS, N. SP.

Plate V, *fig.* 3, *symmetrical side.*

General form of body and arms subovate; basals very small and extending but slightly beyond the column; subradials so small as to allow the middle of the first radials to come in contact with the basals, and yet they project up sharply between the radials; primary radials four to each ray, which increase in width but not in length, the first one being rather longer than the second, and the second a little longer than the third, and the latter as long as the fourth; there are three secondary radials in some of the rays, and four in others; the next bifurcation of the rays takes place on the third, fourth or fifth plate, as shown in our example; the sutures between the plates are moderately sinuous; regular interradials two, the first one long and situate between the first, second and third primary radials on one side, and the second, third and fourth on the other, the second being a little smaller, extending to the second secondary radial, but not truncating it; column round, tapering a little below the calyx, and showing minute crenulations, caused by the furrows on the articulating faces of the plates. Other parts unknown.

Found in the Keokuk Group, near Canton, Indiana, and now in the collection of Wm. F. E. Gurley.

FORBESOCRINUS SPECIOSUS, N. SP.

Plate V, *fig.* 8, *symmetrical side view; fig.* 9, *basal view.*

Species of medium size; plates highly convex or tumid, and depressed at the sutures; sutures between the radials sinuous; calyx constituting more than half the length of the body, though wider than high; basals small; subradials small but extending one angle high between the radials, reaching nearly to the first azygous plate; primary radials four in each series, plates more than twice as wide as high, the first one heptagonal, the second and third hexagonal by reason of joining two interradials at each end, and the fourth pentagonal and supporting upon its two upper sinuous, sloping sides the secondary radials; secondary radials three in each series, twice as wide as high, the first two hexagonal, the third heptagonal, the two upper sinuous edges sloping very little; tertiary radials from four to eight in the different rays, and the next division more unequal and irregular, the bifurcation not taking place in some rays until the tenth or twelfth plate is reached. Throughout the rays the sutures are sinuous, the upper face being concave; the sutures are all well defined; the ends of the arms are infolded; regular interradials about twenty in each area, the first one the larger and resting upon the upper sloping faces of the first two primary radials; this is followed by two plates, and these by three, and above these the plates are polygonal of unequal size and extend as high as the commencement of the tertiary radials; intersecondary radials from four to six; intertertiary radials two, one following the other in direct line; azygous area like the regular interradial areas, except it may be slightly wider in the middle part.

Found in the Keokuk Group, in Washington County, Indiana, and now in the collection of William F. E. Gurley.

Cyathocrinus opimus, n. sp.

Plate V, fig. 5, symmetrical side, natural size.

Species short and plump; calyx one-half wider than high, plates smooth, sutures in depressions; basals forming a flattened pentagon about twice as wide as the thickness of the column; subradials more than three times as large as the basals, larger than the first radials, standing upright, highly convex, and protuberant; first radials one-half wider than high, rounded, pentagonal, truncated nearly the entire width above, and having a deeply concave outward sloping facet for the reception of the brachial pieces. There are two brachials in each of the two rays preserved in our specimen; the first is wide and thin, and is separated from the first radial by a gaping suture; the second is equally as wide but a little higher, and supports upon its upper sloping sides free arms. The arms are robust, round, and each one bifurcates again on the second plate; two of these bifurcate again on the second plate, and one is observed to bifurcate on the third and another on the fourth, and the other arms are so injured that the bifurcations can not be determined. The arms after each bifurcation are of unequal size and bifurcate irregularly. The plates of the arms are slightly constricted in the middle, making the arms angular externally, and the sutures are slightly gaping, or one plate projects slightly beyond the other. The arm on the left of the two described does not divide on the second brachial, but it is not exposed so as to allow proper definition. The column is round, a small part of the ventral sac is exposed on the right side of our specimen; the azygous side and other parts of this species are unknown.

This species will be readily distinguished by its short, plump form, nipple-like subradials and the frequent bifurcations of the arms. It is not without some hesitation that it is referred to the genus Cyathocrinus.

Found in the Keokuk Group at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

Poteriocrinus arcanus, n. sp.

Plate V, fig. 4, symmetrical view.

This species has a rather long, subcylindrical head, when the arms are closed. Calyx obconoidal, plates rounded, sutures depressed, basals bent upward from the column and forming a small cup; subradials larger than the basals or first radials, as long as wide and rounded so as to leave the sutures in depressions; first radials wider than high, convex, sutures depressed, upper face horizontally truncated the entire width of the plate, and suture gaping; second radial or brachial longer than wide, rounded, constricted and supporting upon its upper sloping sides the free arms; arms ten, long, rounded externally, and slightly flattened on the sides so as to permit them to close tightly together; plates long and very slightly cuneiform below, but becoming shorter and more cuneiform above; pinnules short and coarse; column round and composed of thicker and thinner plates. Azygous side and proboscis unknown.

Found in the Keokuk Group, in Washington County, Indiana, and now in the collection of Wm. F. E. Gurley.

SCAHPIOCRINUS BONOENSIS, N. SP.

Plate V, fig. 6, symmetrical side; fig. 7, azygous side.

All the plates of the body and arms are angular and present a very rough aspect; calyx low, plates sharply angular in the central part, and sutures in angular depressions; basals small, hidden by the column; subradials about as high as wide, standing nearly upright; hexagonal, except the one on the azygous side, which is truncated at the top and heptagonal, and each one is produced into an angular node at the central part; first radials pentagonal, about one third as high as wide, sharply angular at the upper central part, horizontally truncated the entire width of the plate on top, where the suture is gaping; second radials quadrangular, about one-third as long as wide, sharply angular, longitudinally, in the central part, sutures gaping; third radials pentagonal, about half as high as wide, sharply angular in the central part and supporting arms upon the upper sloping sides.

The arms divide on the sixth plate, except one which appears to be abnormal and bifurcates on the eighth; above this the bifurcations are not uniform, one arm after each bifurcation does not again divide, while the other one continues to divide to the sixth bifurcation; the divisions are all on one side of an arm, which, commencing from the third primary radial, we may call the inner side, for the single or non-bifurcating arms are thrown toward each other in each of the five radial series as in Zeacrinus; the arms are angular externally, each plate having a sharp node on the upper central part, those on which the bifurcation of the arms takes place being most prominent. The plates are slightly cuneiform, and the nodes do not, therefore, follow each other in direct line, but project slightly on one side and then on the other in zigzag order.

The azygous plates are sculptured, the central part of each being the most prominent; the first one is inserted obliqely between a subradial and a first and second radial; the second azygous plate is much larger than the first, and truncates a subradial; above this the plates are as usual in this genus. The column is pentagonal and plates nodose.

Found in the Keokuk Group, at Bono, Indiana, and now in the collection of Wm. F. E. Gurley.

Abrotocrinus, n. gen.

Ety.: abrotos, immortal; krinon, lily.

Calyx low, bowl-shaped; basals five, occupying a shallow concavity; subradials hexagonal, as high as wide; first radials pentagonal, wider than high, truncated horizontally the entire width of the plates, sutures gaping; brachial or second radial constricted in the middle and bearing upon its upper sloping sides the free arms; arms bifurcate frequently and bear pinnules; no regular interradials. First azygous plate of the same form and in line with the first radials, resting between the upper sloping sides of two subradials, horizontally truncated the entire width above and having a gaping suture; second azygous plate constricted in the middle and horizontally truncated on top; above this numerous plates form a single longitudinal series until they graduate into the proboscis. Column obscurely pentagonal at the head and becoming round below.

This genus probably belongs to the family Poteriocrinidæ, type A. cymosus.

Abrotocrinus cymosus, n. sp.

Plate V, fig. 2, azygous side view, natural size.

This is a large species, having a low calyx, in proportion to the great length of the arms, and a peculiar enlargement of the plates at each bifurcation of the arms, giving them a knobby aspect; plates granulous, not sculptured, sunken at the angles, and sutures well defined; calyx low, bowl-shaped, height about half the diameter; basals occupying a concavity at the bottom; subradials bending abruptly upward, having a height equal to the greatest width; first radials pentagonal, pointed below; about twice as wide as high, horizontally truncated at the top the entire width and having a gaping suture; second radials or brachials pentagonal, larger than the first radials, nearly as long as wide, rounded externally, constricted at the sides, very tumid in the upper central part, with steep upper sloping sides for the free arms.

The first arm plates are rapidly contracted from the top of the second radials so as to leave a convex knob-like elevation at the bifurcation; the arms are round externally and bifurcate on the seventh and eighth plates; they increase in size toward the bifurcation, and at the point of bifurcation become proportionally more tumid than the rays are at the division on the second radials. Both arms bifurcate at regular distances, so that there are more than fifty arms before the divisions cease to take place, and there is a swelling at every bifurcation similar to the last above described. Below the bifurcations the plates are round, externally, and very slightly cuneiform, but above the last bifurcation the plates become quite cuneiform, and more or less nodose in zigzag lines, as is common with the arms of Scaphiocrinus. Pinnules long and numerous.

First azygous plate as large as a first radial, and of the same form, with a gaping suture at the top; second azygous plate rapidly tapering upward and horizontally truncated at the top. Above this ten plates are visible in a single longitudinal series before the series is covered by the overlapping arm on the right. Column obscurely pentagonal near the calyx, but soon becoming round below; the central canal is pentagonal, and a circle of denticulations exists on the articulating face of each plate just within the periphery.

Found in the Keokuk Group, in Washington County, Ind., and now in the collection of Wm. F. E. Gurley.

GONIOCRINUS, N. GEN.

Ety.; gonia, an angle; krinon, lily.

Calyx small, basin-shaped, plates convex or angular; basals five, small, extending beyond the column; subradials five, about the same size as the basals; first radials larger, wider than long, and supporting on the slightly concave upper faces, a little shorter than the width of the plates, the brachials; brachials, three in each ray, flanged at the sides; arms resembling Scaphiocrinus. No regular interradials; azygous interradials, consisting of a series of plates, the first one like a first radial and resting upon the upper truncated face of a subradial, which is followed by plates very much like the brachials, which form a convex arm-like appendage that curves in toward the proboscis at or above the base of the free arms. A small azygous plate also exists on the right side of the area, resting between the upper sloping sides of the two subradials and the under sloping sides of a first radial and the azygous plate which truncates a subradial. Column pentagonal, bearing cirrhi, composed of thicker and thinner plates; canal pentagonal. Type G. sculptilis.

GONIOCRINUS SCULPTILIS, N. SP.

Plate VI., fig. 2, symmetrical side, natural size; fig. 3, same magnified more than two diameters; fig. 4, left side of another specimen magnified a little more than two diameters; fig. 5, azygous side of same.

Calyx small, short, basin-shaped, truncated at the top; plates thick, angular, sutures sunken at the angles; basals five, small, extending beyond the column and forming a rim at the base of the calyx; subradials five, about the same size as the basals, angular, sutures depressed and sunken at the angles; first radials wider than high, convex longitudinally, angular, sutures depressed and sunken at the angles; slightly concave facet above, about two thirds the width of the plates, for the articulation of the brachials; brachials, three in each ray, the second one a little longer than the first, and the third longer than the second, and bearing upon its upper sloping sides the free arms; the central part is convex and the sides flanged, but the different series do not come in contact, and the plates of the proboscis may be seen, in our specimens, between the brachials. Arms ten, angular, plates flanged, and giving off armlets or remarkably long, coarse pinnules, at irregular distances, generally on the second or fourth plate, but never alternately. These armlets are supported on the sloping sides of arm-plates axillary in character, and are composed of short plates. A small, quadrangular azygous plate is inserted between the upper sloping sides of two subradials and the under sides of the right first radial and the second azygous plate; the second azygous plate truncates a subradial and is in line with the first radials and of about the same size; the three following plates are of the same size as the brachials and form a prominent, convex ridge to the third brachials, when the series abruptly curves under the arms. Column pentagonal, and bears numerous cirrhi; columnar canal pentagonal, the angles of the pentagon notching the basal plates and corresponding with a pentagonal opening that separates the subradials.

Found in the Waverly or Kinderhook Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

It is quite likely the species described as Cyathocrinus harrisi should be referred to this genus. It is certainly nearer to this genus than it is to Cyathocrinus. We refer this genus to the Poteriocrinidæ.

BATOCRINUS POCULUM. N. SP.

Plate VI, fig. 6, symmetrical side, showing part of the arms; fig. 7, azygous side view, showing the broken end of the proboscis; two broken arms are crowded out of place to the right.

Calyx urn or bowl-shaped, medium size, vault moderately convex, proboscis small, subcentral; plates granular, sutures so indistinct as to be traced with difficulty; basals thick, depressed for the column below, and forming a smooth rim at the base, without indented sutures; first radials very large, nearly as high as wide, two hexagonal and three heptagonal, smooth, sutures indistinct, upper face very slightly arcuate; second radials quadrangular, short; third radials a little larger than the second, but both together not as large as a first radial; secondary and tertiary radials small.

Arms twenty, large, composed of a double series of interlocking plates, above the second tertiary radials; pinnules long, numerous; arm openings to the vault directed outward at right angles to the calyx.

Regular interradials four, the first one very large, irregular, having eight unequal sides; this is followed by two rather small elongated plates, and these by a minute plate. Azygous area very large, bulging out, the first plate in line with the first radials and of the same size and form; this is followed by three plates, larger than second primary radials, and these by four, the central two being small and nearly on a line with the third primary radials, and these are followed by three small plates. Possibly there may be one or two minute plates above these, but if so the sutures in our specimen are too indistinct for their determination.

The vault is moderately convex, but slightly depressed toward the proboscis, and composed of unequal polygonal, convex plates. Proboscis small, cylindrical, and near the lower end composed of smooth, elongated plates. Column round and radiately furrowed toward the circumference, as shown by the plate within the basal depression of our specimen.

Found in the Waverly or Kinderhook Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS FACETUS, N. SP.

Plate VI, fig. 8, view of the right side of a specimen, showing there are only three arms in the first radial series on the right of the azygous side.

Calyx medium size, half globular below the arms and conical above, with a subcentral proboscis, plates convex and more or less angular, sutures depressed; basals forming a pentagonal disc nearly covered by the column; first radials about one-half wider than long, upper face concave; second radials quadrangular, nearly as long as the first radials; third radials about as large as the first radials, and supporting on the upper slightly sloping sides the secondary radials; second secondary radials wider than the first secondary radials and of about the same length; two tertiary radials in each of the three series, the second one having the characters of a brachial. There are no tertiary radials in the series opposite the azygous side, and consequently there are only two arms in that series, and there are tertiary radials in only one branch on the right of the azygous area, and hence there are only three arms in that series. Arms seventeen, long, composed of a double series of interlocking plates bearing long pinnules.

Regular interradials four, the first one large and having nine sides; this is followed by two plates, each of which is longer than wide, and these by a single plate. Azygous area wide and having eleven plates; the first one is as large as a first regular interradial; it is truncated on top by a small quadrangular plate and bears upon each of its upper sloping sides a plate fully as large as itself; these are followed by three smaller plates, the central one being the larger, and these again by three smaller ones, which are followed by a single plate resting between the upper sloping sides of the two plates on the right of the area. There are two small intersecondary plates in the right radial series, seeming to fill the space that would have been occupied by the regular plates if there had been four arms in the series instead of three. The vault is covered with unequal, tumid, polygonal plates. Column round, composed of thicker and thinner plates; columnar canal pentagonal. Height of proboscis unknown.

Found in the Keokuk Group, near Canton, Indiana, and now in the collection of William F. E. Gurley.

BATOCRINUS CANTONENSIS, N. SP.

Plate VI, fig. 9, azygous side, showing proboscis.

Calyx medium size, obconical below the arms and conical above, with a large, long, subcentral proboscis, plates conical or having angular nodes in the form of transverse ridges, base truncated; basals large, thick, forming a wide rim at the bottom, indented at the sutures, first radials a little wider than high; hexagonal, convexity in the form of a transverse ridge; second radials small, quadrangular, half as wide as the first radials; third radials small, pentagonal, very short, a little wider than the second radials and bearing upon the upper sloping sides the secondary radials; two secondary radials in each ray, wider than high, having transverse angular nodes, the upper plates each bearing upon the upper sloping sides a single tertiary radial; the tertiary radials have a concave upper face supporting the free arms.

Arms twenty, openings to the vault directed upward. Above the first two plates the arms consist of a double series of interlocking plates, flattened on the external face of the arms, and toward the upper part more or less depressed and the interlocking ends of the plates bearing small nodes. Pinnules long, numerous.

Regular interradials three, one following the other; first one as large as a first radial, very protuberant and having nine sides; the second one about half as large, and hexagonal or pentagonal; the third one small, pentagonal and situate between the second secondary radials and abutting the under sloping sides of the tertiary radials. Azygous area wide, interradials seven; the first one heptagonal, resting between the upper sloping sides of two basals and between the first radials, and supporting three azygous plates, the one on the right being the larger. These are followed by three plates, the one on the right being also the larger one, and extending its upper angle between the under sloping sides of the tertiary radials.

The vault and proboscis are composed of very nodose, almost spiniiform plates. The proboscis extends beyond the end of the arms. Column round, composed of thicker and thinner plates, the former projecting beyond the latter; columnar canal pentagonal.

Found in the Keokuk Group, near Canton, Indiana, and now in the collection of Wm. F. E. Gurley.

Poteriocrinus spartarius, n. sp.

Plate VII., fig. 1, *view of the right side, showing part of the azygous area and part of the column.*

Calyx low, somewhat obconoidal, one-half wider than high, sutures distinct, plates smooth; basals low, forming a pentagon about one-half wider than the thickness of the column with the angles sharply elevated between the under sloping sides of the subradials; subradials a little wider than high, one on the azygous side heptagonal, the others probably hexagonal; first radials one-half wider than high, rounded, pentagonal, articulating surfaces occupying the entire width of the plates, and sutures gaping; each ray has two brachials; the first one is the larger, a little wider than long and rounded externally; the second is shorter than the first, rounded and supports upon its two steep sloping sides the free arms; the arms are rounded externally, bifurcate twice, making forty arms, and are composed of slightly cuneiform plates; the first bifurcation takes place on the eighth plate in some rays, and on the tenth plate in others; above this the bifurcations are irregular, and occur from the fourteenth to the twenty-eighth plates; pinnules numerous, but rather small for the size of the arms.

The azygous area is rather wide, the first plate is pentagonal, a little smaller than a subradial, rests upon the upper sloping sides of two subradials and between the first radial on the right and the azygous plate on the left, and is truncated at the top for the third azygous plate; the second azygous plate is pentagonal, about as large as the first, rests upon the truncated upper end of a subradial and between a first radial on the left and the first and third azygous plate on the right, and is truncated at the upper end for the fourth plate; the third azygous plate is hexagonal, rests upon the first azygous plate with the first radial and first brachial on the right and the second and fourth azygous plate on the left, and above this the plates graduate into the proboscis.

Column round and bearing long cirrhi at irregular distances from each other.

The specimen illustrated is on a slab and looks much like a little broom, which suggested the specific name.

Found in the Kinderhook or Waverly Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

POTERIOCRINUS SCOPÆ, N. SP.

Plate VII., fig. 2, azygous side.

Calyx low, somewhat obconoidal, about twice as wide as high, sutures distinct, plates smooth, basals low, upright; subradials about as wide as high, one on the azygous side heptagonal, the others probably hexagonal; first radials one-half wider than high, rounded, pentagonal articulating surfaces occupying the entire width of the plates, and sutures gaping, a single brachial in each ray, longer than wide, rounded externally and contracted on both sides, bears upon its upper sloping sides the free arms; the arms are rounded externally, bifurcate twice, making forty arms, and are composed of slightly cuneiform plates; the first bifurcation occurs on the eighth plate; the second bifurcation takes place in each arm from the tenth to the eighteenth plate; pinnules numerous but not large.

The azygous area is very wide and displays a wide proboscis; the first plate is pentagonal, a little smaller than a subradial, rests upon the upper sloping sides of two subradials and between the first radial on the right and the second azygous plate on the left, and is truncated at the top for the third azygous plate; the second plate is pentagonal, about as large as the first, rests upon the truncated upper end of a subradial, and between a first radial on the left and the first and third azygous plate on the right, and is truncated at the upper end for the fourth plate.

Column round, and bears long cirrhi at irregular distances from each other. The resemblance to a little broom suggested the specific name.

This species is distinguished from P. spartarius by having only one brachial plate in each ray, a lower calyx, and wider proboscis and azygous area.

Found in the Kinderhook or Waverly Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

POTERIOCRINUS GENISTA, N. SP.

Plate VII, fig. 3, azygous side.

Calyx low, somewhat obconoidal, more than twice as wide as high, sutures distinct, plates smooth, basals low, slightly spreading; subradials about twice as wide as high, one on the azygous side heptagonal, the others probably hexagonal; first radials one-half wider than high, rounded, pentagonal, articulating surfaces occupying the entire width of the plates, and sutures gaping; there is a single brachial in the ray on the right of the azygous area, rounded externally, contracted in the middle and bearing upon its upper sloping sides free arms; the ray on the left of the azygous area has two brachials, the first one is the larger, a little wider than long, rounded externally and slightly contracted in the middle, the second is shorter than the first, rounded, and supports upon its upper sloping sides free arms; the arms are rounded externally, bifurcate twice, making forty arms, and are composed of slightly cuneiform plates; the first division takes place in some arms on the sixth plate, and in others on the eighth plate; the second division takes place in each arm from the tenth to the twentieth plate; pinnules rather small.

The azygous area is very wide and the plates are arranged as in P. scopæ; column round and bears long cirrhi at irregular distances. The resemblance to a little broom suggested the specific name.

This species is much like P. scopæ, and possibly should not be separated from it, but it is distinguished from it by having two brachials in the ray on the left of the azygous area instead of one, and differs in some of the details of the arm structure, especially in having the first division in some of the arms take place on the sixth plate instead of the eighth. The specimens of *P. spartarius*, *P. scopæ* and *P. genista*, which we have illustrated, are on the same slab, which also bears two other specimens of *P. spartarius* and one of *P. scopæ*. They are all light-colored. The slab is from Le Grand, Iowa, and is in the collection of Wm. F. E. Gurley.

POTERIOCRINUS LEGRANDENSIS, N. SP.

Plate VII, fig. 4, symmetrical side, natural size; fig. 5, symmetrical side, magnified; fig. 6, azygous side, magnified.

Species small, calyx obconoidal, height about two-thirds the greatest diameter, plates smooth, basals small, forming a low pentagonal cup; subradials comparatively large, height and width sub-equal; first radials nearly as high as wide, very convex and much depressed at the separating sutures, so as to give them the appearance of brachials, truncated the entire width above, and separated from the brachials by a ping suture; a single much-elongated brachial, rounded, and contracted in the middle, supports upon its upper sloping sides, in each radial series, the free arms.

The arms divide on the sixth plate, making twenty arms. The arms are rounded, plates comparatively long, cuneiform, and project alternately for the attachment of coarse pinnules, which gives the arms a rough aspect. Azygous area wide, and plates arranged as in other species of this genus. Column, round.

Found in the Waverly or Kinderhook Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

POTERIOCRINUS CANTONENSIS, N. SP.

Plate VIII, fig. 3, symmetrical side; fig. 4, azygous side, but the figure is slightly incorrect, as the first plate rests between the upper sloping sides of the subradials, and the artist mistook a blemish for the suture.

This species is very slender, and, including the arms, when not compressed, nearly cylindrical; calyx forms a little cup having thick, somewhat angular plates, depressed toward the sutures; basals small, forming a flattened pentagonal disc about twice the diameter of the column; subradials larger, standing nearly upright, and depressed at the sutures; first radials much larger than the subradials, convex, and projecting externally near the upper face, where they are truncated the full width, and have gaping sutures separating them from the single brachial plates; brachial plates long, contracted in the middle, and having very steep upper sides for the articulation of the free arms; arms ten, no division, and composed of a single series of plates, which are long in proportion to the size of the arms, the first one being very long; azygous plates rather small, the first one having an unusually long side abutting upon the second plate, but as usual in this genus, it rests between the upper sloping sides of the subradials and the under sloping side of the right first radial; the second azygous plate is very long and narrow, being so nearly pointed below that it slightly truncates the subradial. By reason of an injury to our specimen at this place, the artist mistook the lines made by the blemish for the sutures, and overlooked the true suture lines, so there is a slight error in the illustration in this regard. Column, round.

Found in the Keokuk Group, near Canton, Indiana, and now in the collection of Wm. F. E. Gurley.

ONYCHOCRINUS CANTONENSIS, N. SP.

Plate VII., fig. 9, azygous side, natural size.

Calyx low, basin-shaped, plates smooth, sutures distinct; basals three, extending beyond the column, forming a pentagon one-third wider than the diameter of the column; subradials five, comparatively small; not more than half the size of the first radials, two of them pentagonal, two hexagonal and one on the azygous side heptagonal, with sides unequal, the upper one being sinuous in the middle for the reception of a small azygous plate; radials five in each series, well rounded, wider than high, very gradually tapering to the bifurcation on the fifth plate, sutures transverse between the first, second and third plates, but sinuous in the middle part of the fourth; arms or secondary rays very short, the bifurcations taking place on every third plate until the extremities are clustered together like a little, clinched fist at the end of each radial series; the sutures between each of the arm plates are slightly sinuous in the middle part; first regular interradial about the size of a subradial; others not determinable from our specimen; azygous interradials very small, our specimen showing seven plates in a row; column round, composed of thin plates in the upper part, tapering in size downward for a short distance, when the plates become proportionally thicker and finally having a thickness equal to half the diameter of the column, articulating faces of the plates connected near the surface of the column by fine radiating lines which give the sutures a crenulated aspect.

Found in the Keokuk Group, near Canton, Indiana, and now in the collection of Wm. F. E. Gurley.

RHODOCRINUS SCULPTUS, N. SP.

Plate VII., fig. 11, view of the azygous area, right radial series and one interradial area.

Calyx deep, bowl-shaped, sides swelling but little, plates thickened, convex, and pointed in the center with more or less well defined ridges connecting the subradials and radials, sutures depressed; basals small, extending but little beyond the column; subradials comparatively large, thick, upright, giving the base of the calyx a truncated aspect, pointed or highly convex at the central part of each, with a ridge extending to the adjoining first radials; first radials about two-thirds as large as the subradials, pointed in the center, and bearing a ridge connecting them with the second radials; second radials smaller, quadrangular, a little longer than wide and bearing a central longitudinal ridge; third radials pentagonal, about the same size as the second radials, convex in the central part and bearing a single secondary radial upon each of the upper sloping sides; secondary radials pentagonal, about as large as the third primary radials, and supporting free arms, which, at first, are directed almost at right angles to the top of the calyx; the arms bifurcate on the fifth plate, and the adjoining arms in each radial series again bifurcate on the third plate, giving to the species thirty arms; arms small, short, rounded externally, and composed of a single series of short plates in the lower part, but above the second axillary plate, composed of a double series of interlocking plates. Pinnules strong and numerous.

Regular interradials, seven, the first one pentagonal, a little smaller than a first radial, and pointed in the center; this is followed by two smaller plates, and these by two that fill the space between the third radials, and these by two smaller ones that connect with the plates of the vault. Azygous interradials, seven, the first one hexagonal, larger than a first radial, pointed in the center, with ridges connecting it with adjoining plates; this is followed by three plates, the middle one extending higher than the others, and these by three smaller plates. A ridge extends from the subradial over the plates in the central part of the azygous area, as distinctly marked as that which crosses the three primary radials.

The calyx of this species resembles that of R. kirbyi, but our specimen is light colored, while all of the kirbyi from the same locality are dark colored. It is distinguished by having no second secondary radial or brachials and by the smaller and differently constructed arms.

Found in the Kinderhook or Waverly Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

RHODOCRINUS CÆLATUS, N. SP.

Plate VII, fig. 10, *view of azygous area, right radial series and an interradial area.*

Calyx deep, bowl-shaped, plates sculptured, and bearing prominent radial ridges that give it a somewhat pentagonal outline; sutures depressed; basals small, extending but little, if any, beyond the column; subradials comparatively large; first radials larger than the subradials, heptagonal, and bearing ridges that radiate to each adjoining plate; second radials hexagonal, less than half the size of the first radials, a little smaller than the second, pentagonal, and supporting upon each of the upper sloping sides a single secondary radial; secondary radials about the same size as the third primary radials, pentagonal, protuberant, and support free arms; the arms are round externally, and bifurcate on the fifth plate; the first four plates are cuneiform and have gaping sutures; there are twenty arms, and above the bifurcation they are composed of a double series of interlocking plates; pinnules numerous and strong.

Regular interradials, seven; the first one pentagonal, much smaller than a first radial; it is followed by two smaller plates, and these by two, and the latter by two smaller ones that unite with the plates of the vault. Azygous area wider between the secondary radials, and plates larger than in the regular interradial areas.

Column large, round, and composed of thicker and thinner plates, the former of which projects beyond the latter.

The calyx of this species resembles that of R. nanus, though the plates are more deeply sculptured, and differ some in their relative proportions, while the arms are much like those of R. watersianus. Our specimen is light colored. Certain species from Le Grand are invariably dark colored, while others are invariably light colored. This is a peculiarity not known to us as prevailing at any other locality.

Found in the Waverly or Kinderhook Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

Zaecrinus dubius, n. sp.

Plate VII, fig. 7, symmetrical side; fig. 8, azygous side.

Calyx very small in proportion to the other parts of the body, forming a low cup, not half as high as wide, plates smooth, convex, sutures distinct, and generally beveled; basals forming a small disc scarcely extending beyond the column; subradials small, first radials larger than subradials, one-half wider than high, convex, and much depressed at the side suture, giving them the appearance of brachials, truncated the entire width above, the suture gaping; two brachials in each ray of about the same size as a first radial, the upper one being axillary for the support of the free arms.

The arms divide twice, making thirty arms, the divisions take place from the outer arm in each radial series, while the inner arms or branches remain single. The arms are round externally, and composed of cuneiform plates having a height equal to about half the diameter of the arm. Pinnules small. Azygous area rather wide and convex, with plates arranged as in Poteriocrinus and Scaphiocrinus. The proboscis, or ventral sac, extends to the top of the arms, where it is crowned with large convex plates, and, in this respect, resembles Zeacrinus, as it does also in the manner of the bifurcation of the arms.

If we were to look only at the azygous area, and disregard the fact that the basal plates are sunken at the bottom of the calyx, and probably form a low conical elevation in the interior, we would refer this species to Poteriocrinus. But we regard the position of the basal plates as of great importance, and think no species having the basal plates sunken so as to be hidden from a side view of the calyx, should be referred to Poteriocrinus. In other words, the genus Poteriocrinus should be held to include only species having an obconoidal calyx. The calyx of this species agrees with Scaphiocrinus, but the arms and proboscis agree with Zeacrinus. Probably it should not be classed with either genus, but we are not prepared, in the present state of mixed learning respecting the Poteriocrinidæ, to propose a new generic name. What we have said here applies with equal force to Poteriocrinus granilineus, described on page 343 of this article. We there suggested the species might belong to the branch for which Wachsmuth had suggested the name Pachylocrinus, overlooking the fact that on page 241 of Part III, of his Palæocrinoidea, he had stated that his Pachylocrinus is a synonym for Woodocrinus. (Parisocrinus, on page 239, is doubtless a typograghical error for Pachylocrinus, or an accidental oversight.) We have not, at present, access to the work of DeKoninck on Woodocrinus, and have little confidence in the amended diagnosis by Wachsmuth.

Found in the Keokuk Group, at Bono, Ind., and now in the collection of Wm. F. E. Gurley.

SCAPHIOCRINUS REPERTUS, N. SP.

Plate VIII, fig. 1, symmetrical side; fig. 2, azygous side.

Calyx basin-shaped, plates convex, smooth, sutures distinct; basals forming a slightly depressed pentagonal disc, extending a little beyond the column; subradials comparatively large, convex, smooth, and forming a little cup; first radials a little larger than the subradials, one-fourth wider than high, highly convex, with a transverse, central, concave depression, truncated the entire width above, and having a projecting rim, and gaping suture above; single brachials wider than high, constricted in the middle, bear upon their upper, sloping sides the free arms.

Arms, ten; small when compared with the brachials and proboscis, and composed of long, constricted cuneiform plates, alternately projecting for the support of the coarse pinnules. The arms are so small as to be incapable of covering the proboscis, which may be seen between them wherever the coarse pinnules are removed. Azygous area has rather large plates arranged as in other species of this genus. The third, fourth and fifth azygous plates in our specimen are perforated with a round opening immediately adjoining the first arm plate on the right, and the proboscis, where visible, is indented at the angles of the plates. Column small, round, and plates radiately furrowed at the outer circumference. Most nearly allied to S. depressus.

Found in the Keokuk Group, at Bono, Indiana, and now in the collection of Wm. F. E. Gurley.

Scaphiocrinus bellus, n. sp.

Plate VIII, fig. 5, azygous side; fig. 6, symmetrical side; fig. 7, basal view.

This species is remarkable for its deeply sculptured and highly angular plates of calyx and arms.

Calyx low, basin-shaped, nearly three times as wide as high, plates convex and deeply sculptured; basals forming a flattened pentagonal disc nearly one-half wider than the diameter of the column; subradials larger than the basals, highly convex, deeply sculptured, extending below the basal disc and reaching up half the height of the calyx; an angular ridge extends from the center of each plate to meet another on the adjacent radials, and one is also directed toward each of the abutting basal plates; first radials twice as wide as high, deeply sculptured, having a central elevation from which a ridge extends to the abutting subradials, truncated above the entire width, suture widely gaping, showing great thickness in the upper part of the plate, with ligamental furrows or denticulations on the upper face and on the under side of the brachials.

A single brachial in each ray, wide below, where it articulates with the radials, heighth and width subequal, constricted on the sides, so as to form a sharp longitudinal ridge in the middle, supports upon the steep upper sloping sides the free arms. Arms ten, long, coarse, separated from each other, plates slightly cuneiform and bearing alternately long, strong pinnules; the first plate is long, constricted on the sides, so as to form a sharp longitudinal ridge in the center, that does not unite with the longitudinal ridge on the brachial below, nor the one on the succeeding arm plate; a wide, gaping suture separates the first arm plate from the brachial, and exposes the same kind of ligamental furrows or denticulations that exist between the brachials and first radials. All the plates of the arms are constricted at the sides and bear a longitudinal ridge in the middle, but the ridges do not connect so as to make a continuous longitudinal keel on the arms, but are arranged in a zigzag line.

Azygous area wide, depressed, plates deeply sculptured and arranged as in other species of this genus. A small part of the flattened proboscis is exposed at and near the top of our specimen. Column pentagonal, sides concave, central canal obscurely pentagonal.

Found in the Keokuk Group, at Bono, Indiana, and now in the collection of Wm. F. E. Gurley.

Scaphiocrinus lacunosus, n. sp.

Plate VIII, fig. 8, symmetrical side; fig. 9, azygous side; fig. 10, basal view.

Calyx low, basin-shaped, plates thick, sculptured, protuberant, sutures depressed, sunken at the angles; basal plates forming a pentagonal, depressed disc, extending but little beyond the column; subradials rather large, extending below the basals, and upward half the height of the calyx, sharply sunken at the angles; radials pentagonal, more than twice as wide as high, sculptured, deeply sunken at the angles, concave on the upper face, which extends the full length of the plates, upper margin projecting in a rim, which is separated from the first brachial by a gaping suture. Two brachials in each ray, the first quadrangular and twice as wide as high; the second short, pentagonal, and supporting on its upper sloping sides the free arms.

The arms on some of the rays divide five times, the division taking place from the outer arm, while the inner ones continue single; in other rays, especially in the one upon the right of the azygous area, some of the inner arms bifurcate, hence there are more than fifty arms. The arm plates are cuneiform, rounded externally, contracted on the sides and project at the upper side of the thicker end for the support of the pinnules. Pinnules coarse.

Azygous area wide, plates arranged as in other species of this genus, sculptured and depressed at the angles. Column large, pentagonal, composed of projecting thicker and thinner plates, with a small round central canal.

It most resembles S. briareus, from the upper geodiferous shales of the Keokuk Group, at Keokuk, Iowa.

Found in the Keokuk Group, at Bono, Indiana, and now in the collection of Wm. F. E. Gurley.

SCAPHIOCRINUS PRÆMORSUS, N. SP.

Plate VIII., fig. 11, *symmetrical side view.*

Calyx low, basin-shaped, plates highly convex, angles sunken, sutures depressed; basals small, forming a depressed pentagonal disc extending but little beyond the column; subradials small, thick, extending below the basals and forming a low cup with upper angles projecting half the height of the first radials; first radials twice as wide as high, sunken at the angles, truncated the entire width above with a projecting rim and very wide, gaping suture. A single brachial in each ray, sharply angular, longitudinally, and contracted at the sides, supports on steep upper sloping sides the free arms, except in the radial series, opposite the azygous side, where the brachial is truncated above and supports a single arm. The arms are angular externally, sutures very marked, plates cuneiform and bear short, very coarse pinnules. The ray opposite the azygous side bifuracates on the fourth plate, and again on the sixth plate, making four arms to the ray; the other rays bifurcate on the sixth plate, making six arms to each of the four radial series, which gives to the species twenty-eight arms.

Found in the Keokuk Group, in Washington County, Indiana, and now in the collection of Wm. F. E. Gurley.

DICHOCRINUS ULRICHI, N. SP.

Plate VIII., fig. 12, side view; fig. 13, azygous side.

Calyx obconoidal, very slightly inflated above the middle of the first radials, a little higher than wide, sutures slightly depressed so as to give the plates a little convexity, surface apparently smooth; basals form a little cup, not quite as wide as high, the notch at the union of the basals on the azygous side being a little deeper than it is on the opposite side; first radials a little longer than wide, and increasing in width very slightly toward the upper end where each has a concave facet full two-thirds of the width of the plate for the articulation of the brachial plates. There is only one brachial, in our specimen, in the ray opposite the azygous side, but, possibly, two plates have been anchylosed, though no evidence of a suture can be detected. The first brachials are quite as thick as the second, which bear the arms upon the upper sloping sides. Arms ten, long, robust, rounded externally and composed of a single series of thin plates very slightly cuneiform. Pinnules very coarse and closely packed together.

Regular interradials or interbrachials form part of the vault. First azygous plate hexagonal, a little narrower above than below, and slightly arched toward the vault; it is followed by two smaller plates, and these by others covering a convex elevation higher than the surrounding part of the vault. Column round.

Attention should probably be called to the fact that Wachsmuth & Springer say, in the generic diagnosis of Dichocrinus, that "the arm plates from the base up are composed of a double series of pieces;" but in Dichocrinus cinctus, described in this paper, the arm plates consist of a *single* series of small pieces, and in the species here described they consist of a single series of wide cuneiform pieces. Again they say the azygous plate is "quadrangular," but in Dichocrinus ulrichi it has two sides below and two above and is hexagonal, and in Dichocrinus cinctus there are two sides below and more than two abutting plates above, and hence it is polygonal. Their generic diagnosis will stand reformation.

Found in the Keokuk Group, at Bono, Indiana, and now in the collection of Wm. F. E. Gurley.

POTERIOCRINUS SUBRAMOSUS, N. SP.

Plate X, fig. 1, azygous side view; where the illustration shows only three plates before there is a bifurcation in an arm, the arms are injured, and probably there should be four plates.

Species robust, calyx obconoidal, expanding gradually from a rather large column, longer than wide, and composed of smooth, rounded plates with well-defined sutures; basals large, standing upright, pentagonal, higher than wide; subradials as long as wide, the one on the azygous side heptagonal, the others probably hexagonal; first radials wider than high, rounded, pentagonal, articulating surface occupying a little less than the entire width of the plates and concave on the upper side for the reception of the brachials; there are three brachials in the rays on the azygous side, rounded, much wider than long, the third one supporting the free arms upon its upper sloping sides; these arms bifurcate again on the fourth plate (those having only three plates in the illustration are injured and restored, and it is doubtful whether there are three or four plates), and these again on the fourth plate, except one arm on the right, which bifurcates on the sixth plate; all the plates are highly rounded, and the sutures are distinct. The arms bifurcate so frequently in the part of our specimen which is preserved that there are evidently thirty or more arms. The first azygous plate is large, hexagonal, rests upon the upper sloping sides of two subradials and between the right first radial and the second azygous plate: the second azygous plate is hexagonal, and about as large as the first azygous plate, and rests upon a subradial and between the first radial on the left and the first azygous plate; these two azygous plates are followed above by three small ones, and above these the proboscis is unknown; column composed of alternately thicker and thinner plates, which are radiately furrowed upon their articulating surfaces, and show the zigzag lines upon the surface of the column. The other side of this species is unknown.

Found in the Keokuk Group, at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

Scaphiocrinus graphicus, n. sp.

Plate X, fig. 4, azygous side view.

Species medium size; calyx bowl-shaped, plates rounded, finely sculptured, sutures distinct; basals extending beyond the column, forming a pentagon one-half wider than the column; subradials longer than wide, expanding and widening a little and constituting nearly the whole body of the calyx; first radials on the azygous side pentagonal, rounded, wider than high, projecting outward toward the upper face, where they are truncated less than the entire width for the reception of the brachials; upper face concave, sutures gaping; first brachial rounded, wider than high, sutures gaping; second brachial longer than wide, rounded constricted, and supporting upon its upper sloping sides the free arms. Arms ten, keeled, finely lined or granulous, plates somewhat constricted, some longer than wide, others wider than long, obliquely truncated at the ends, the upper ends projecting alternately on opposite sides for the support of strong, angular pinnules. Azygous area wide, elongated; first azyous plate pentagonal, resting between the upper sloping sides of two subradials and between the first radial on the right and the second azygous plate; second azygous plate hexagonal, resting upon a subradial and between the first radial on the left and the first and third azygous plates on the right; the third azygous plate rests upon the first azygous plate and between the first radial on the right and the second and fourth azygous plates on the left; the azygous plates are truncated at the top and become gradually smaller above, eight being shown in the specimen described. Column obscurely pentagonal and composed of thicker and thinner plates. Symmetrical side unknown.

Found in the Keokuk Group, at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

SCAPHIOCRINUS GRANULIFERUS, N. SP.

Plate X, fig. 3, symmetrical side view.

Calyx shallow, bowl-shaped, about twice as wide as high to the top of the first radials, base concave, plates convex, sutures depressed, surface granulous; basals small contained within the concave base; subradials as wide or wider than high, highly convex or protuberant and deeply depressed at the sutures, they rise nearly vertically; first radials wider than high, pentagonal, projecting outward at the upper margin, rounded, depressed toward the sutures, truncated the entire width above, and separated on the outside from the brachials by wide, gaping sutures; brachials constricted in the middle, longer than wide, with steep upper sloping sides for the articulation of the arms above. Arms ten, no bifurcations, plates long, some of them more than twice as long as wide, rounded and angulated on the outside, constricted in the middle, obliquely truncated at the ends, with the upper ends projecting alternately on opposite sides for the support of pinnules, composed of very long joints; sutures in the arms gaping; azygous side unknown. Column round, composed of alternately thicker and thinner plates, some of which bear short, round cirrhi.

It is found in the Keokuk Group, at Crawfordsville, Ind., and is now in the collection of Wm. F. E. Gurley.

SCAPHIOCRINUS DISPARILIS, N. SP.

Plate IX, fig. 1, a small specimen; Plate X, fig. 2, a large specimen.

Species medium size, plates smooth or finely granulous, sutures distinct; calyx bowl-shaped, as wide or wider than high; basals extending beyond the column, forming a pentagon nearly twice its diameter; subradials a little larger than the basals, hexagonal, about as wide as high; first radials rounded, heptagonal, nearly one-half wider than high and truncated the entire width above for the support of the brachials, sutures gaping; brachials longer than wide, rounded and constricted in the middle, and supporting upon the upper sloping sides the free arms. Arms ten, plates long, rounded and smooth on the outside; first plate very long; above this they gradually shorten and become cuneiform, and support alternately on opposite sides rather coarse, strong pinnules. The other side unknown. Column round and composed of alternately thicker and thinner plates which are radiately furrowed upon their articulating surfaces.

Found in the Keokuk Group, at Crawfordsville, Ind., and now in the collection of Wm. F. E. Gurley.

Barycrinus princeps, n. sp.

Plate IX, fig. 2, azygous side; fig. 3, opposite side view.

Species very robust, plates smooth, calyx depressed between the radials, sutures distinct, angles of the plates sunken as is usual in this genus; basals moderate size, forming a pentagonal disc half hidden by the column, the portion of each plate exposed, when the column is attached, being but little more than a triangular piece which extends up between the under sloping sides of the subradials; subradials about as wide as high, much larger than the basals, four of them hexagonal and one on the azygous side heptagonal; first radials twice as wide as high, rounded, pentagonal, truncated nearly the entire width above, so as to present a broad, concave or almost half circular outward sloping facet, for the reception of the brachial pieces; the brachials are wide, rounded and thin; there are two in each ray on the azygous side and in the ray opposite thereto, and six in each of the lateral rays; the lateral rays bifurcate on the sixth plate, from the first radial, and the ray opposite the azygous side bifurcates on the second plate above the first radial, and no other bifurcation takes place in these three rays, but it is quite different with the rays on the azygous side. The ray on the right of the azygous side first bifurcates on the second plate from the first radial, and the left arm does not again divide, but the right one bifurcates again on the fourth plate, while the ray on the left of the azygous side first bifurcates on the second plate from the first radial and the right arm does not again divide, but the left one bifurcates again on the fourth plate; when the bifurcation takes place in any of the rays the arms are of equal size, but above these bifurcations moderately strong branches or armlets are given off at intervals of about four plates along their sides, bearing some resemblance to those on Onychocrinus. There are therefore twelve arms, no pinnules. The first azygous plate is quadrangular and rests between the upper sides of two subradials and the under side of the right first radial; the second plate rests between the first radials and truncates a subradial and the first azygous plate. Above this the azygous plates and vault are unknown. It is not without some hesitation that this species is referred to Barycrinus.

Found in the Keokuk Group, at Crawfordsville, Ind , and now in the collection Wm. F. E. Gurley.

ÆSIOCRINUS BASILICUS, N. SP.

Plate IX, fig. 4, symmetrical view; fig. 5, azygous side view, with part of proboscis; fig. 6, basal view.

Calyx half globular or, depressed, bowl-shaped, plates slightly convex, sutures distinct but not beveled except between the radials and brachials and at the axillaries; surface of all the plates of calyx and arms granulous. Basals forming a pentagonal, flattened disc having an outline a little more than twice the diameter of the column. Subradials large, four hexagonal, one heptagonal, curving upward from the basals more than half the height of the calyx, making the upper sloping sides much the longer. First radials pentagonal, twice as wide as high, the under sloping sides about twice as long as the lateral faces, and the upper truncated sides extending to the greatest width of the plates, with a beveled or slightly gaping suture. First brachials short, more than three times as wide as long. Second brachials more than three times as wide as high, with long upper sloping sides for the articulation of the free arms.

The right arms in two of the radial series opposite the azygous side bifurcate on the second plate, the other arms are not preserved in our specimen. There is a small interaxillary plate in one of these arms and a peculiar slit in another arm above the angle of the axillary plate, both of which may be abnormal freaks or the result of some injury. The arm plates preserved in our specimen are not cuneiform, though they may become so nearer the end of the rays.

The proboscis in this species seems to be exactly like the proboscis in Æsiocrinus magnificus. The column is small, pentagonal, the plates articulated on a row of denticulations near the margin, and it is probable that otherwise it agrees with the column in the type species.

It is readily distinguished from the other known species by the lower calyx and increased number of arms.

Found in the Upper Coal Measures at Kansas City, Missouri, and now in the collection of Wm. F. E. Gurley.

Delocrinus hemisphericus, Shumard.

Plate X, fig. 5, view of head with nearly complete arms.

We have illustrated this specimen to show the arms and spines, because heretofore this part of the species has not been figured. It is from Kansas City, and is in the collection of Wm. F. E. Gurley.

Ulocrinus, sp.

Plate X, fig. 9, shows the circular cavity on the lower side of the anchylosed basals for the insertion and attachment of the end of the column; figs. 10 and 11 show the pentagonal opening through the anchylosed plates and radiating muscular impressions. Fig. 11 is magnified 6½ diameters; fig. 12 shows the convexity on the inner side of the basal plates; figs. 12 and 13 show the peculiar denticulations upon the edges of the plates. Fig. 13 is a magnified view, 6½ diameters.

The plates here described and illustrated belong to an undefined species of Ulocrinus, which we have not seen fit to name for want of more perfect specimens. Part of the characters represented by the illustrations we believe to be not only of generic but of family importance, and also to throw some light upon the structure of palæozoic crinoids at a point which has been substantially overlooked. It will be observed that the plates are of the same size and are anchylosed, which we believe to be the case in all species of this genus.

The external side of the basal plates of this species is almost flat, while the internal side has a convexity greater than the thickness of the plates. The base of the crinoid is thus strengthened by the thickening of the plates around the part to which the column attached and by the anchylosis of the basal plates. There is an external circular depression into which the end of the column was inserted, and this depression is surrounded by a rim to afford further strength to the point of union between the column and the body of the crinoid. At least three plates of the column were inserted in this circular depression, one of which had an extended rim beyond the column that filled a circular furrow on the interior of this depression which locked the column in the basal plates. The first plate of the column at the base of this circular depression is thin and radiately ridged to interlock with the second plate.

The rays of the opening on the internal side of these plates are flanged so as to enlarge the end of the columnar canal, as it passes through the basal plates, or to put a head on it, as it were; this enlargement is also surrounded by a rim for some kind of muscular attachment and to give strength to this part of the body. On the outside of this rim there are radiating, ligamental furrows or vascular markings for the attachment of the animal sarcode, while all other parts of the interior of the calyx are smooth and free from any such scars.

The plates of the calyx of Ulocrinus are large and thin compared with those of Eupachycrinus and without any such beveled external sutures which may have been filled with tissues to strengthen the body as exists in the latter genus. But we find peculiar denticulations upon the edges of all the plates of the calyx, which must have served to hold the plates in their places and give strength to the body. These are shown by fig. 13, magnified 6½ diameters.

EUPACHYCRINUS MAGISTER, MILLER AND GURLEY.

Plate X, fig. 7, basal plates as seen from below; fig. 6, as seen in the interior of the calyx, and fig. 8, side view showing interior conical form of basals.

It will be observed that the plates are of about the same size, and form a conical elevation in the interior of the calyx, pierced at the summit by a pentagonal opening for the columnal canal, with the rounded angles truncating the ends of the plates. The plates are anchylosed. The pentagonal opening is surrounded with ligamental scars or radiating ligamental lines, while the other parts of the internal sides of the plates are smooth The internal sides of subradials and radials are smooth, and show no indications of muscular scars. We believe the basal plates of mature specimens of this genus are always anchylosed, which gave greater strength to this part of the body than it would have had without the anchylosis. The last plates of the column, in all our specimens, are connected with the basals, showing that they were firmly attached during the life of the animal. The only ligamental attachment of the animal to the test of the calyx was probably this one to the basal plates immediately surrounding the entrance from the columnar canal. The other plates of the calyx surrounded the sarcode and kept it in place.

SCHOENASTER LEGRANDENSIS, N. SP.

Plate IX, fig. 7, ventral view; fig. 8, dorsal view; fig. 9, part of ventral side magnified 6½ diameters.

Body thin, regularly pentagonal, sides concave, with long, narrow, gradually tapering convex arms. Plates on the dorsal side of the disc in our specimen apparently anchylosed, and spines, if any belonged to the margin, broken away. Ventral side depressed and flat between the arm furrows, where it consists of very small plates, and if they imbricate inward the overlap must be very slight. Ambulacral furrows wide, deep; two rows of subquadrangular, ambulacral plates form the bottom of each furrow, on each side of which there is a row of oblong ambulacral plates, having an obliquely inward imbricating arrangement, presenting somewhat the appearance of a twisted cord; these are continued to the ends of the arms with the same obliquely inward, imbricating arrangement. Five pairs of oral plates.

This species is small in comparison with the two heretofore described, has sides less convex, and narrower arms.

Found in the Waverly or Kinderhook Group, at Le Grand, Iowa, and now in the collection of Wm. F. E. Gurley.

AGANASTER, N. GEN.

Ety.: agan, very much; aster, star.

Plate IX, fig. 10, *dorsal view of Aganaster gregarius, with points of rays broken off; fig.* 11, *dorsal side of arm magnified.*

In 1869 Meek and Worthen described an Ophiuroidea, in the Proceedings of the Academy of Science of Philadelphia, p. 169, under the name of Protaster gregarius, which they redefined and illustrated in the Geological Survey of Illinois, vol. V, p. 509, under the name of Protaster (?) gregarius. They had numerous specimens "in the condition of casts and molds, in a very fine, somewhat granular matrix, that did not show the details of its structure very clearly," but they said, "It will probably be found to be generically distinct from the Silurian typical forms of Protaster, but we prefer to place it provisionally in that genus for the present." In the collection of Mr. Gurley there are several specimens belonging to this species, and they show a few characters not observed by Meek and Worthen, and demonstrate very clearly this species does not belong to the genus Protaster; we therefore propose to include this species in a new genus, Aganaster, and describe the characters, so far as known, as follows:

General outline, a central circular disc with five long, narrow rays; the circular disc on the dorsal side is covered with small polygonal plates which are not interrupted by the presence of the rays, thus showing the disc had a depth greater than the depth of the rays; rays very narrow and convex or half cylindrical, spine-bearing, gradually tapering and from the dorsal side appear as if composed of plates arranged exactly opposite each other; the ventral side shows a rather deep central disc with marginal plates. There are ten oral plates in the central part of the disc. Type, A. gregarius.

AGANASTER (?), SP.

Plate IX., fig. 12, *ventral side; fig.* 13, *part of same magnified.*

We have figured this fragment to show the anchylosis of the oral plates, and the pores passing through the ambulacral plates, and also those passing between them. It will be observed that one pore passes through each plate near the marginal end, while a double row of pores passes between the plates in the central part of the arm furrow. We believe this is an Aganaster, from the depth of the central part of the disc, and the arrangement of the plates in the arm furrows; but the specimen is larger than any Aganaster gregarius we have seen and the rays are wider, and as we do not know the position of the pores in the rays of Aganaster, it may be our specimen does not belong to this genus.

TROOSTOCRINUS NITIDULUS, N. SP.

Plate IX., fig. 14, *a small specimen; fig.* 15, *a large specimen with lower end broken off, Plate X., fig.* 14, *summit view.*

Calyx very slender, subfusiform, five-sided, pyramidal above, very slightly tapering, sides flat, triangular below, very small and triangular at the base with a central circular depression, surface apparently smooth.

Basals forming a triangular cup, one angle of which is on the right of the anal side; the cup is a little more than one-fourth the length of the calyx, notched at the top for the abutting radials. Radials more than two-thirds the length of the calyx, not as sloping as the basals, increase in thickness from below upward, forks a little more than one-third the length and end in sharp points at the extreme upper part of the calyx, with sides standing at right angles above the ambulacra. Oral or deltoid plates not visible in our specimen. Each radial sinus is deep and extends downward less than half the length of the radials, and contains between thirty and forty pore pieces or side plates in a double alternating row. Summit, narrow; mouth central, circular; spiracles or ovarian openings small; anal aperture large, elongated, and truncates two radial limbs.

Found in the St. Louis Group, at Lanesville, Indiana, and is now in the collection of Wm. F. E. Gurley.

ARCHÆOCIDARIS LEGRANDENSIS, N. SP.

Plate X, fig. 15, *natural size.*

This species is founded upon the fragment of a body, and our justification for naming and describing it is to be found in the fact that it is the oldest Archæocidaris known in America, and carries this genus back to the lowest Subcarboniferous deposits, whereas, heretofore, it has not been known below the Burlington Group. The fragment has all the characters of the genus so far as the interambulacral plates can show them.

Body evidently small, interambulacral plates small, hexagonal as far as observed; central tubercle occupying about half the diameter of a plate, projecting up twice as high as the ridge at the margin of the plate and perforated in the centre; annular ring at the base obscure, but having a concave depression around it and a distinct elevation toward the margin; marginal nodes obscure, spine very long, round, smooth, contracted a little near the lower end, and slightly swelling just above the contraction, and then very gradually tapering to the end; an expanded base or thickened annulation marks the point of attachment. Ambulacra unknown.

Found in the Kinderhook or Waverly Group, at LeGrand, Iowa, and now in the collection of Wm. F. E. Gurley.

EXPLANATION OF PLATES.

PLATE 1.

EUPACHYCRINUS MAGISTER, N. SP.

Page 328.

Fig. 1. Basal view.
Fig. 2. Azygous side view.

EUPACHYCRINUS SPHÆRALIS, N. SP.

Page 329.

Fig. 3. Basal view.
Fig. 4. Azygous side view.

ULOCRINUS BUTTSI, N. SP.

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Fig. 5. Azygous side view.
Fig. 6. Basal view.

ULOCRINUS KANSASENSIS, N. SP.

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Fig. 7. Azygous side view.
Fig. 8. Outline view regular side.
Fig. 9. Top view of calyx to show the prolongation of the first radials and contracted opening of the calyx.
Fig. 10. Basal view.

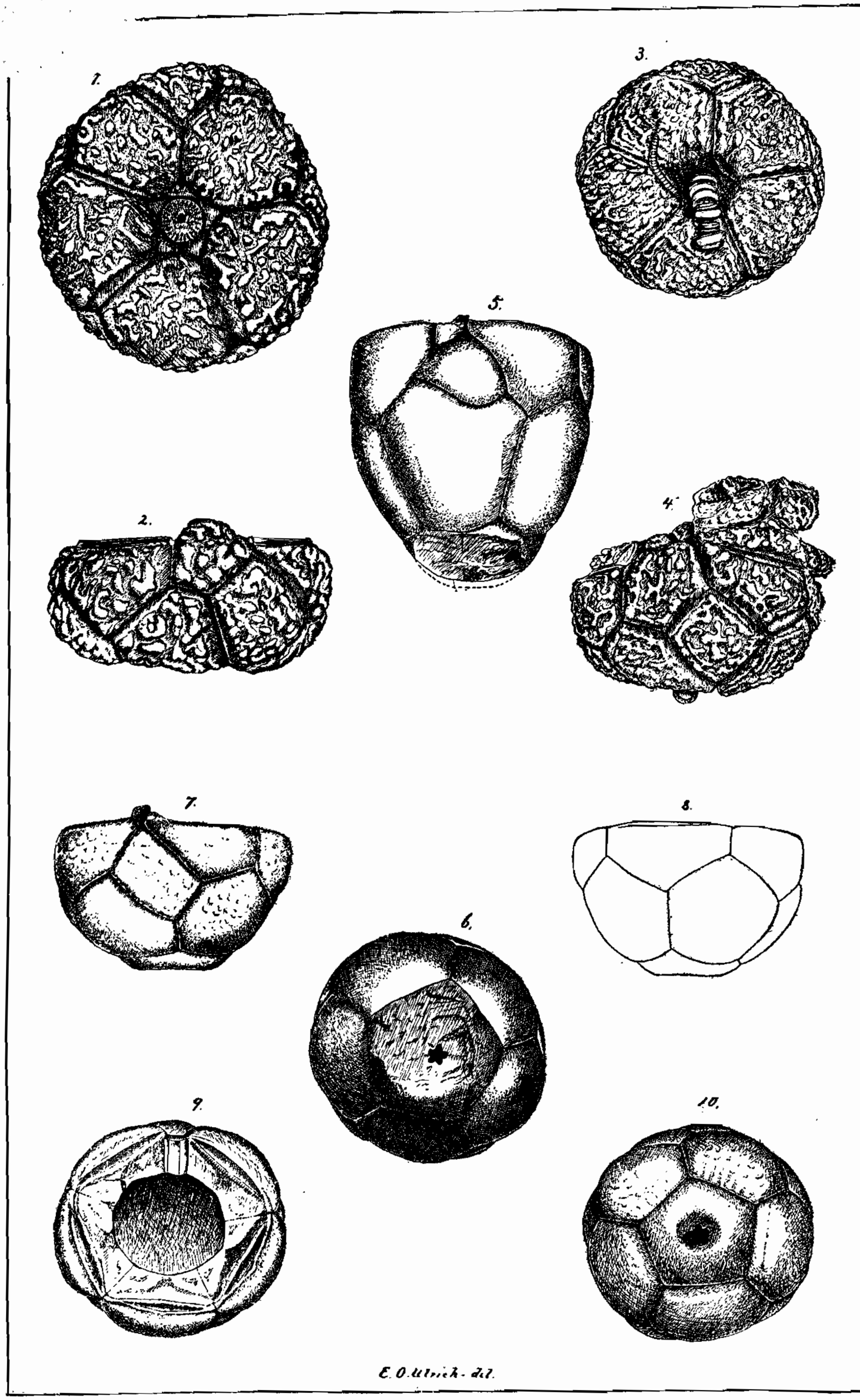
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PLATE 2.

ÆSIOCRINUS MAGNIFICUS, N. SP.

Page 337.

Fig. 1. Natural size of a specimen as it lies on a slab.
Fig. 2. A free proboscis nearly entire and only slightly twisted.
Fig. 3. Portion of same magnified two and one-half diameters to show more distinctly the respiratory openings.
Fig. 4. An abnormal branching proboscis.
Fig. 5. Sectional end view of proboscis.

HYDREIONOCRINUS PENTAGONUS, N. SP.

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Fig. 6. View of azygous side showing height of calyx and upper truncated face for second radials.
Fig. 7. Basal view.

DELOCRINUS HEMISPHERICUS, *Shumard.*

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Fig. 8. Side view showing azygous plate and first brachial, with spine.
Fig. 9. Basal view of same.
Fig. 10. Inner side of brachial spine magnified two diameters.

DELOCRINUS MISSOURIENSIS, N. SP.

Page 336.

Fig. 11. Side view showing column.
Fig. 12. Basal view.
Fig. 13. Azygous side view.

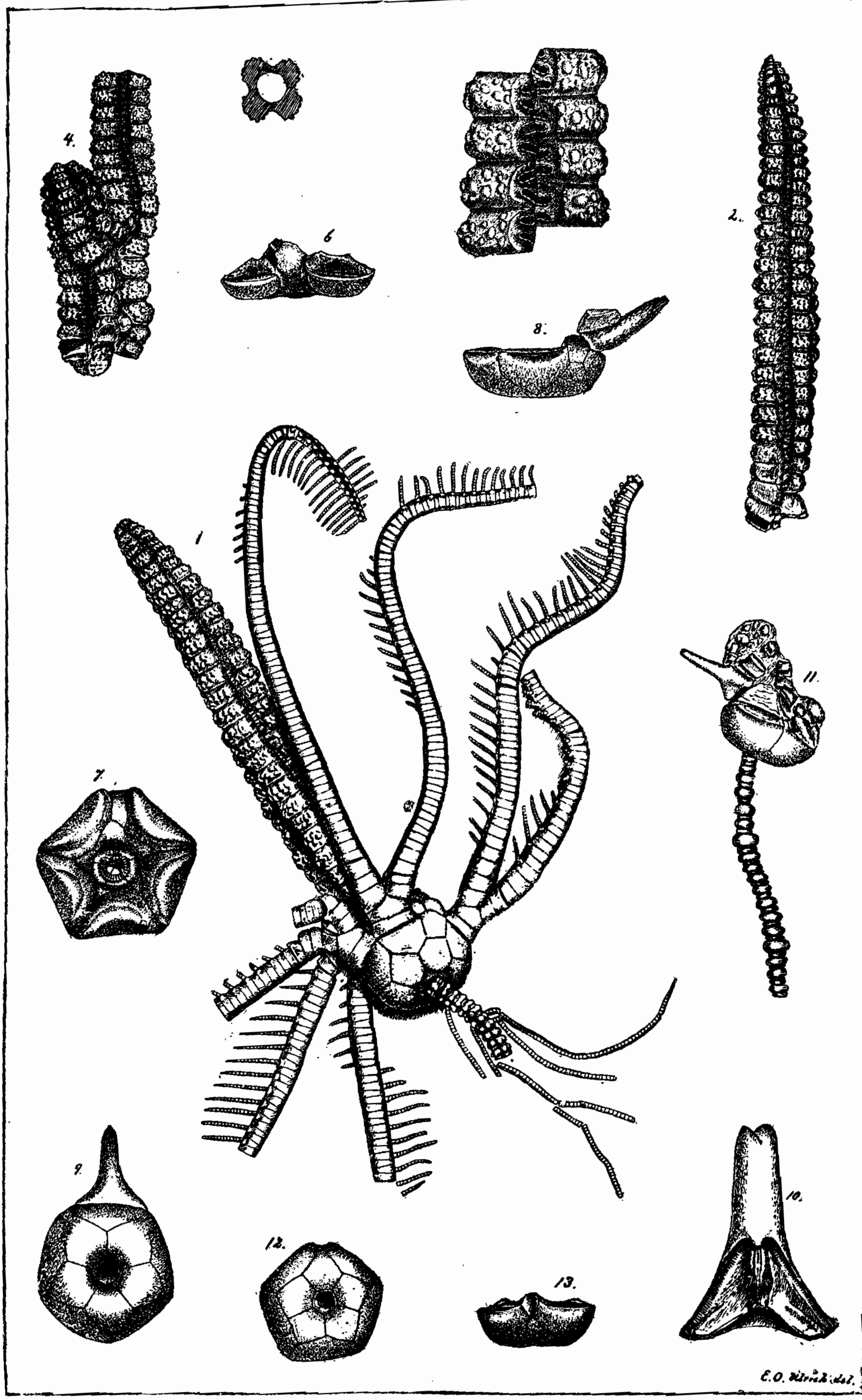
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PLATE 3.

ÆSIOCRINUS HARII, N. SP.

Page 338.

Fig. 1. Natural size as it lies upon a slab.

ONYCHOCRINUS ULRICHI, N. SP.

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Fig. 2. Azygous side.
Fig. 3. Symmetrical side, natural size.

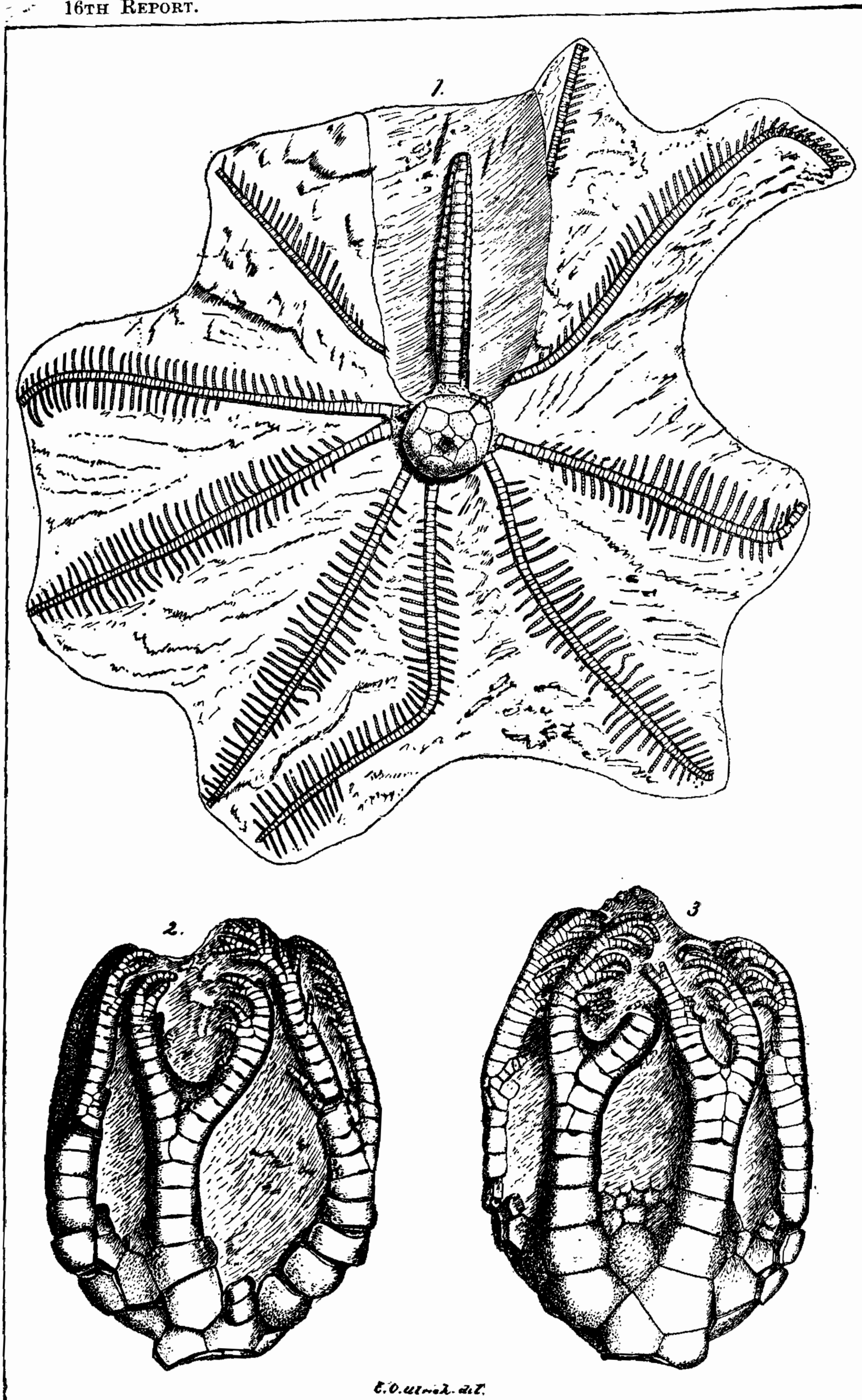
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PLATE 4.

AGARICOCRINUS SPLENDENS, N. SP.

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Fig. 1. Side view, with arms.
Fig. 2. Basal view of same.

BATOCRINUS MARINUS, N. SP.

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Fig. 3. Side and basal view.
Fig. 4. Outline view of plates on azygous side.

BATOCRINUS JUCUNDUS, N. SP.

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Fig. 5. Azygous side, with arms.
Fig. 6. Symmetrical view, with arms removed, showing proboscis.

POTERIOCRINUS GRANILINEUS, N. SP.

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Fig. 7. Natural size.

POTERIOCRINUS CRAWFORDSVILLENSIS, N. SP.

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Fig. 8. Natural size.

POTERIOCRINUS VERUS, N. SP.

Page 344.

Fig. 9. Natural size.

DICHOCRINUS CINCTUS, N. SP.

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Fig. 10. Symmetrical side view.
Fig. 11. Azygous side, showing vault and valvular opening.
Fig. 12. Summit view.

SCAPHIOCRINUS MANUS, N. SP.

Page 345.

Fig. 13. Azygous side, natural size.

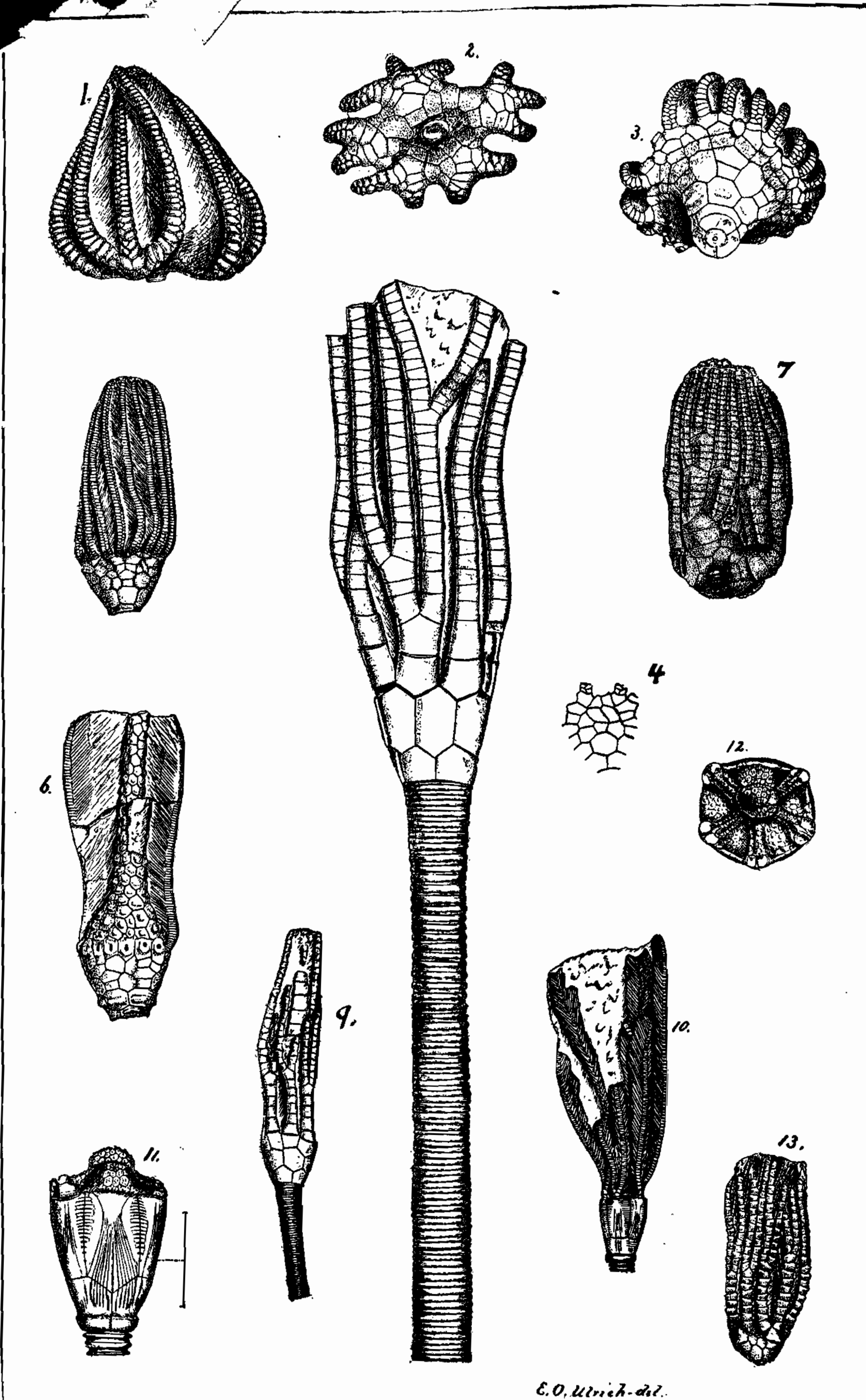
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PLATE 5.

ACTINOCRINUS GRANDIS, N. SP.

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Fig. 1. Symmetrical side, reduced a little below natural size.

ABROTOCRINUS CYMOSUS, N. SP.

Page 350.

Fig. 2. Azygous side view, natural size.

TAXOCRINUS SUBOVATUS, N. SP.

Page 347.

Fig. 3. Azygous side view, natural size.

POTERIOCRINUS ARCANUS, N. SP.

Page 348.

Fig. 4. Symmetrical view.

CYATHOCRINUS OPIMUS, N. SP.

Page 348.

Fig. 5. Symmetrical side, natural size.

SCAPHIOCRINUS BONOENSIS, N. SP.

Page 349.

Fig. 6. Symmetrical side.
Fig. 7. Azygous side.

FORBESOCRINUS SPECIOSUS, N. SP.

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Fig. 8. Symmetrical side view.
Fig. 9. Basal view.

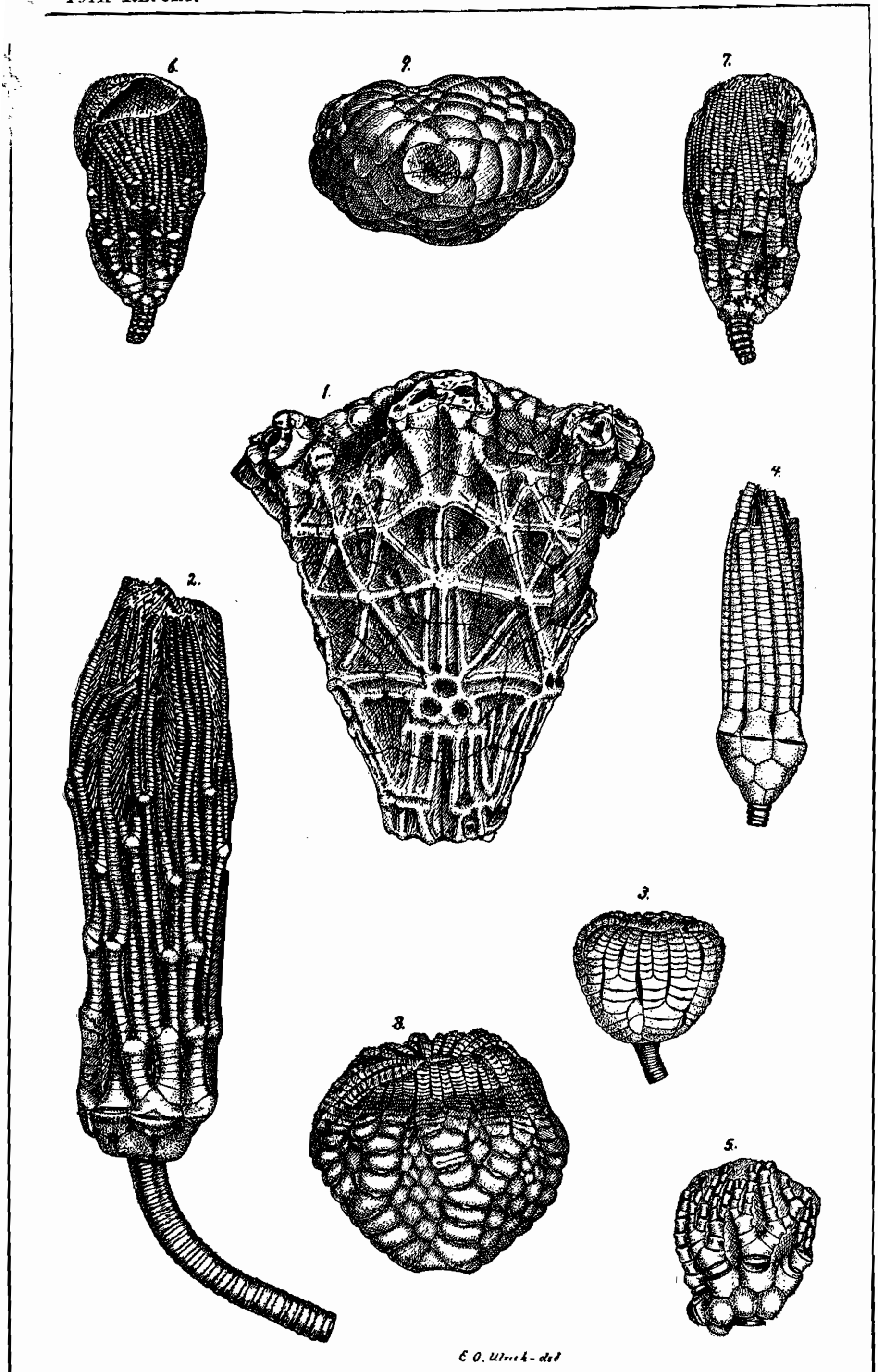
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PLATE 6.

Actinocrinus grandis, n. sp.

Page 346.

Fig. 1. Azygous size reduced a little below natural size.

Goniocrinus sculptilis, n. sp.

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Fig. 2. Symmetrical side, natural size.
Fig. 3. Same, magnified more than two diameters.
Fig. 4. Left side of another specimen magnified a little more than two diameters.
Fig. 5. Azygous side of same.

Batocrinus poculum, n. sp.

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Fig. 6. Symmetrical side showing part of the arms.
Fig. 7. Azygous side view, showing the broken end of the proboscis. Two broken arms are crowded out of place to the right.

Batocrinus facetus, n. sp.

Page 353.

Fig. 8. View of the right side of a specimen, showing there are only three arms in the first radial series on the right of the azygous side.

Batocrinus cantonensis, n. sp.

Page 354.

Fig. 9. Azygous side, showing proboscis.

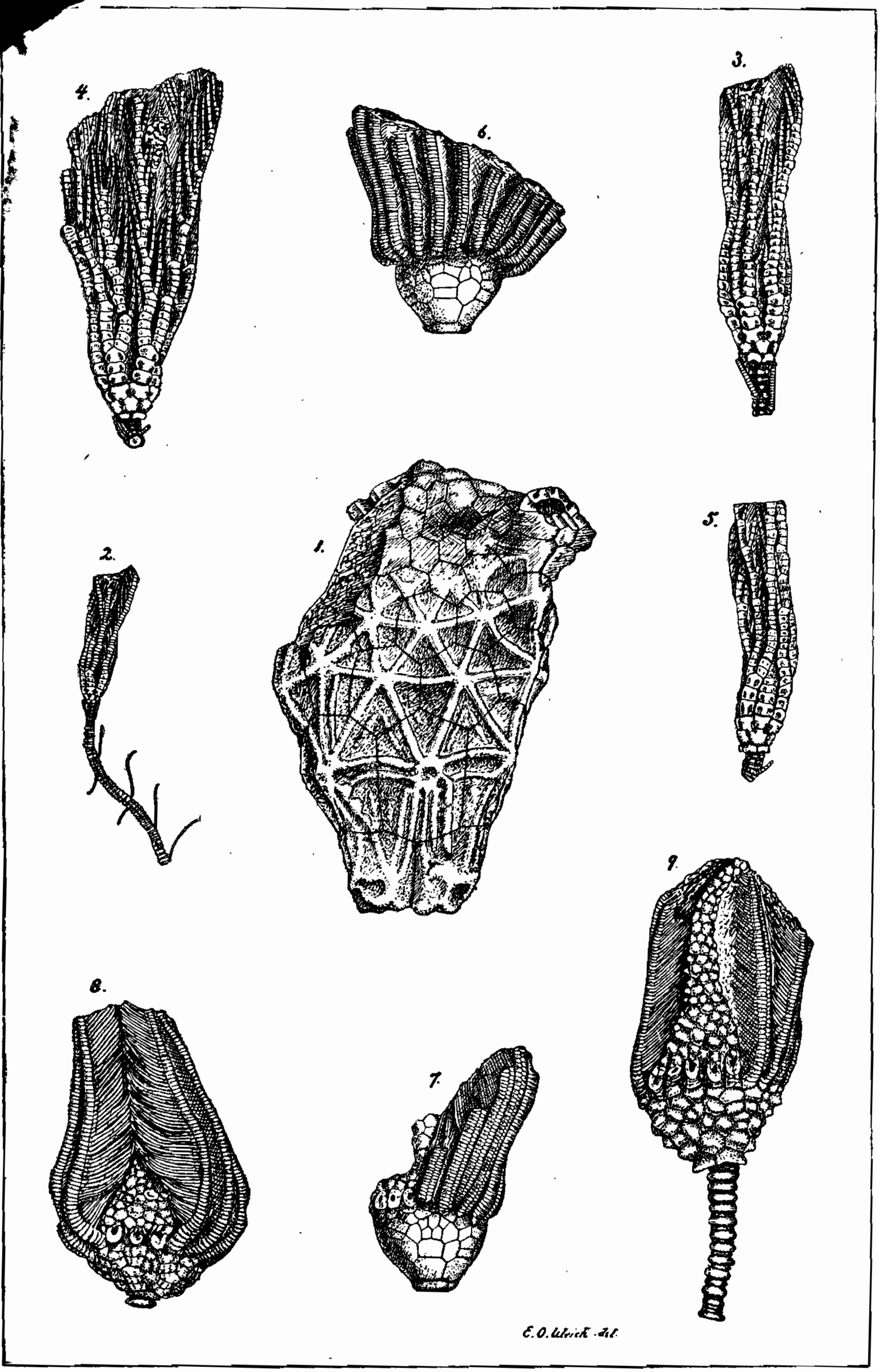
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PLATE 7.

POTERIOCRINUS SPARTARIUS, N. SP.

Page 355.

Fig. 1. View of the right side, showing part of the azygous area and part of the column.

POTERIOCRINUS SCOPÆ, N. SP.

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Fig. 2. Azygous side.

POTERIOCRINUS GENISTA, N. SP.

Page 357.

Fig. 3. Azygous side.

POTERIOCRINUS LEGRANDENSIS, N. SP.

Page 357.

Fig. 4. Symmetrical side, natural size.
Fig. 5. Symmetrical side, magnified.
Fig. 6. Azygous side, magnified.

ZEACRINUS DUBIUS, N. SP.

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Fig. 7. Symmetrical side.
Fig. 8. Azygous side.

ONYCHOCRINUS CANTONENSIS, N. SP.

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Fig. 9. Azygous side, natural size.

RHODOCRINUS CÆLATUS, N. SP.

Page 360.

Fig. 10. View of azygous area, right radial series and an interradial area.

RHODOCRINUS SCULPTUS, N. SP.

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Fig. 11. View of the azygous area, right radial series and one interradial area.

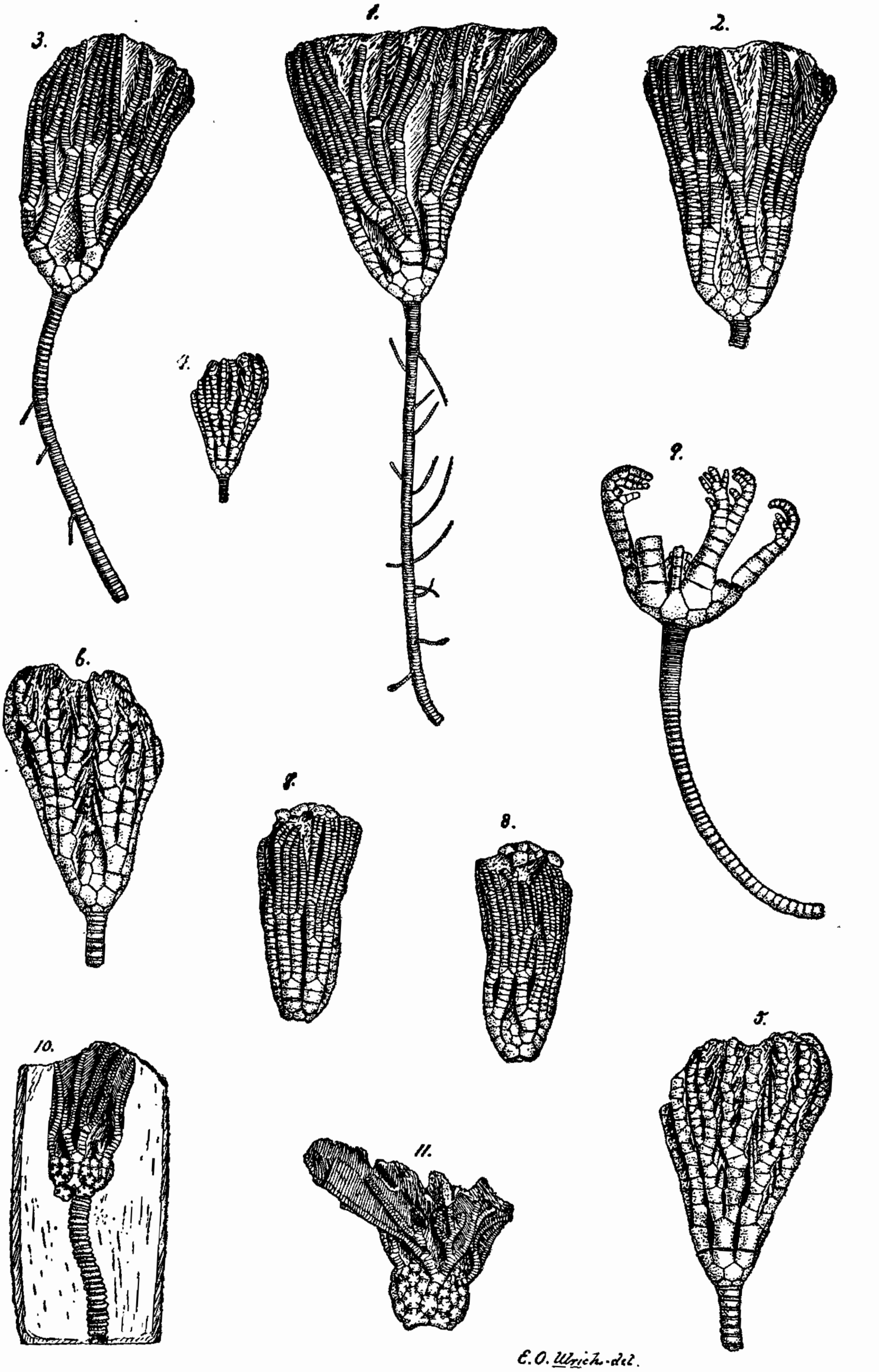

PLATE 8.

SCAPHIOCRINUS REPERTUS, N. SP.

Page 362.

Fig. 1. Symmetrical side.
Fig. 2. Azygous side.

POTERIOCRINUS CANTONENSIS, N. SP.

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Fig. 3. Symmetrical side.
Fig. 4. Azygous side, but the figure is slightly incorrect, as the first plate rests between the upper sloping sides of the subradials, and the artist mistook a blemish for the suture.

SCAPHIOCRINUS BELLUS, N. SP.

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Fig. 5. Azygous side.
Fig. 6. Symmetrical side.
Fig. 7. Basal view.

SCAPHIOCRINUS LACUNOSUS, N. SP.

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Fig. 8. Symmetrical side.
Fig. 9. Azygous side.
Fig. 10. Basal view.

SCAPHIOCRINUS PRÆMORSUS, N. SP.

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Fig. 11. Symmetrical side view.

DICHOCRINUS ULRICHI, N. SP.

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Fig. 12. Side view.
Fig. 13. Azygous side.

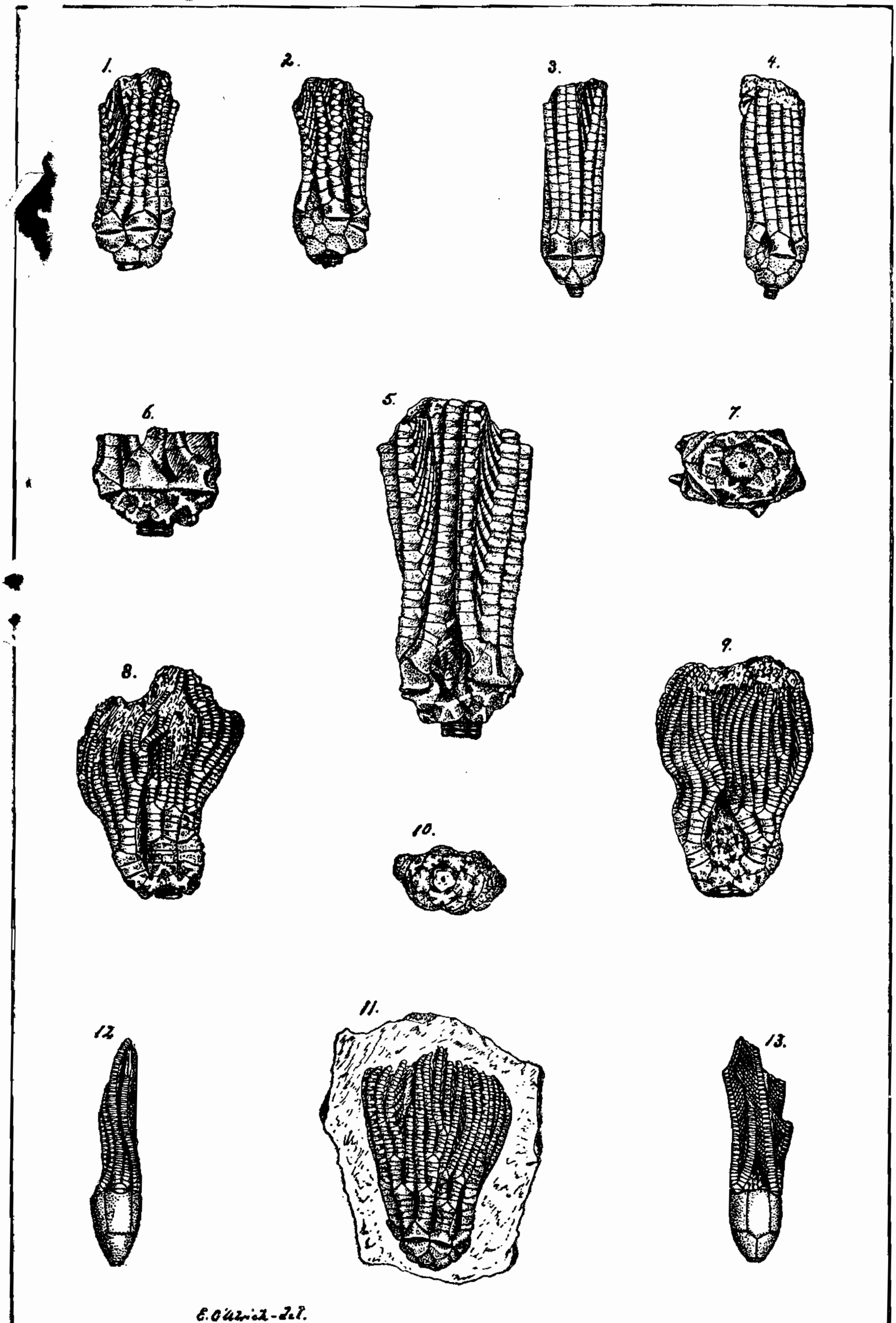
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PLATE 9.

SCAPHIOCRINUS DISPARILIS, N. SP.

Page 367.

Fig. 1. A small specimen.

BARYCRINUS PRINCEPS, N. SP.

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Fig. 2. Azygous side.
Fig. 3. Opposite side view.

ÆSIOCRINUS BASILICUS, N. SP.

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Fig. 4. Symmetrical view.
Fig. 5. Azygous side view, with part of proboscis.
Fig. 6. Basal view.

SCHOENASTER LEGRANDENSIS, N. SP.

Page 371.

Fig. 7. Ventral view.
Fig. 8. Dorsal view.
Fig. 9. Part of ventral side magnified 6½ diameters.

AGANASTER, N. GEN.

Page 372.

Fig. 10. Dorsal view of Aganaster gregarius, with points of rays broken off.
Fig. 11. Dorsal side of arm magnified.

AGANASTER (?) SP.

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Fig. 12. Ventral side.
Fig. 13. Part of the same magnified.

TROOSTOCRINUS NITIDULUS, N. SP.

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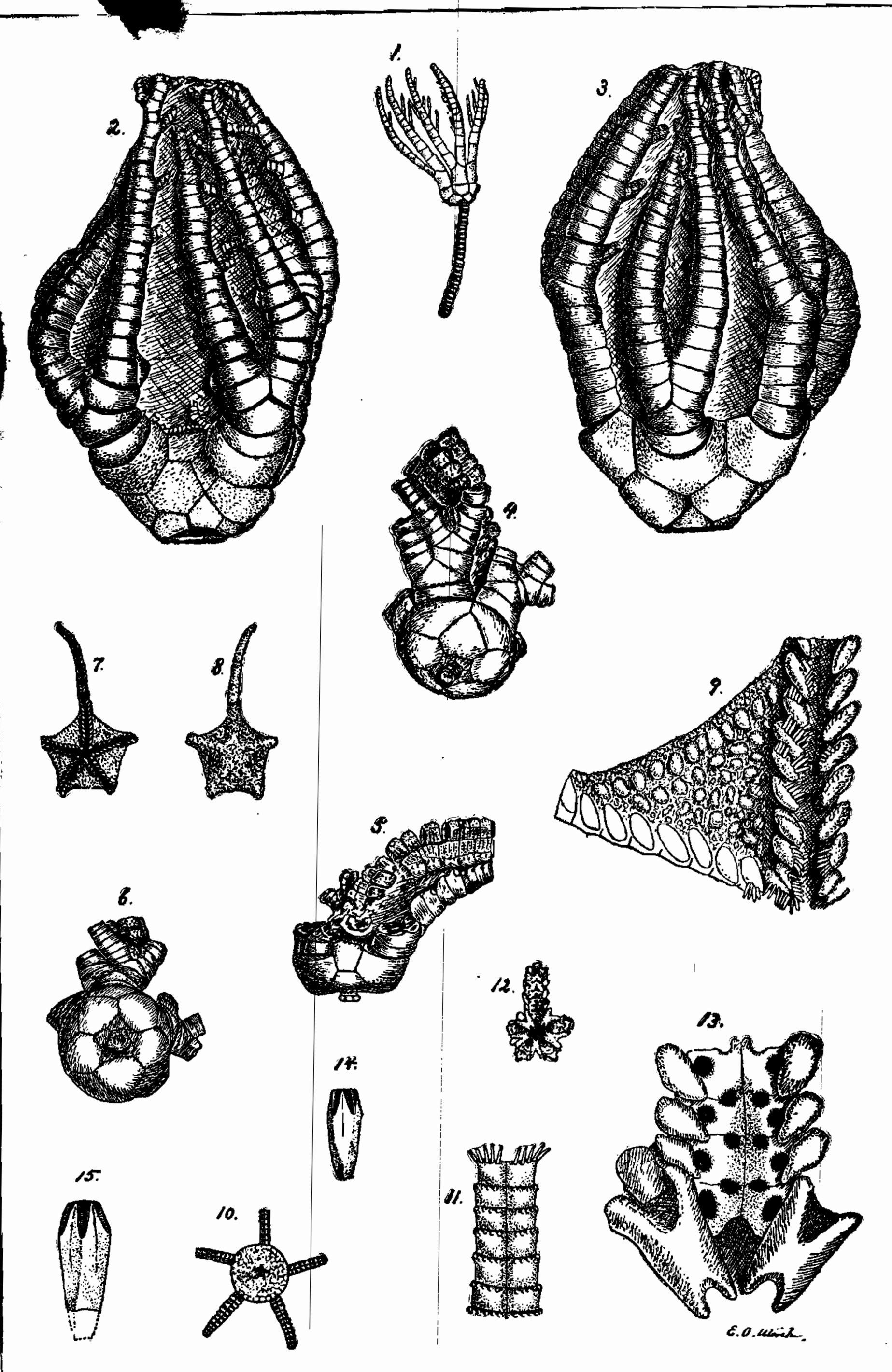
Fig. 14. Is a small specimen.
Fig. 15. A large specimen with lower end broken off.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E. O. Ulrich.

PLATE 10.

POTERIOCRINUS SUBRAMOSUS, N. SP.

Page 365.

Fig. 1. Azygous side view. Where the illustration shows only three plates before there is a bifurcation in an arm; the arms are injured, and probably there should be four plates.

SCAPHIOCRINUS DISPARILIS, N. SP.

Page 367.

Fig. 2. A large specimen.

SCAPHIOCRINUS GRANULIFERUS, N. SP.

Page 367.

Fig. 3. Symmetrical side view.

SCAPHIOCRINUS GRAPHICUS, N. SP.

Page 366.

Fig. 4. Azygous side view.

DELOCRINUS HEMISPHERICUS, *Shumard.*

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Fig. 5. View of head with nearly complete arms.

EUPACHYCRINUS MAGISTER, *Miller and Gurley.*

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Fig. 7. Basal plates as seen from below.
Fig. 6. As seen in the interior of the calyx.
Fig. 8. Side view showing interior conical form of basals.

ULOCRINUS, SP.

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Fig. 9. Shows the circular cavity on the lower side of the anchylosed basals for the insertion and attachment of the end of the column.
Figs. 10 and 11 show the pentagonal opening through the anchylosed plates and radiating muscular impressions.
Fig. 11. Is magnified 6½ diameters.
Fig. 12. Shows the convexity on the inner side of the basal plates.
Figs. 12 and 13 show the peculiar denticulations upon the edges of the plates.
Fig. 13. Is a magnified view, 6½ diameters.

TROOSTOCRINUS NITIDULUS, N. SP.

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Fig. 14. Summit view.

ARCHÆOCIDARIS LEGRANDENSIS, N. SP.

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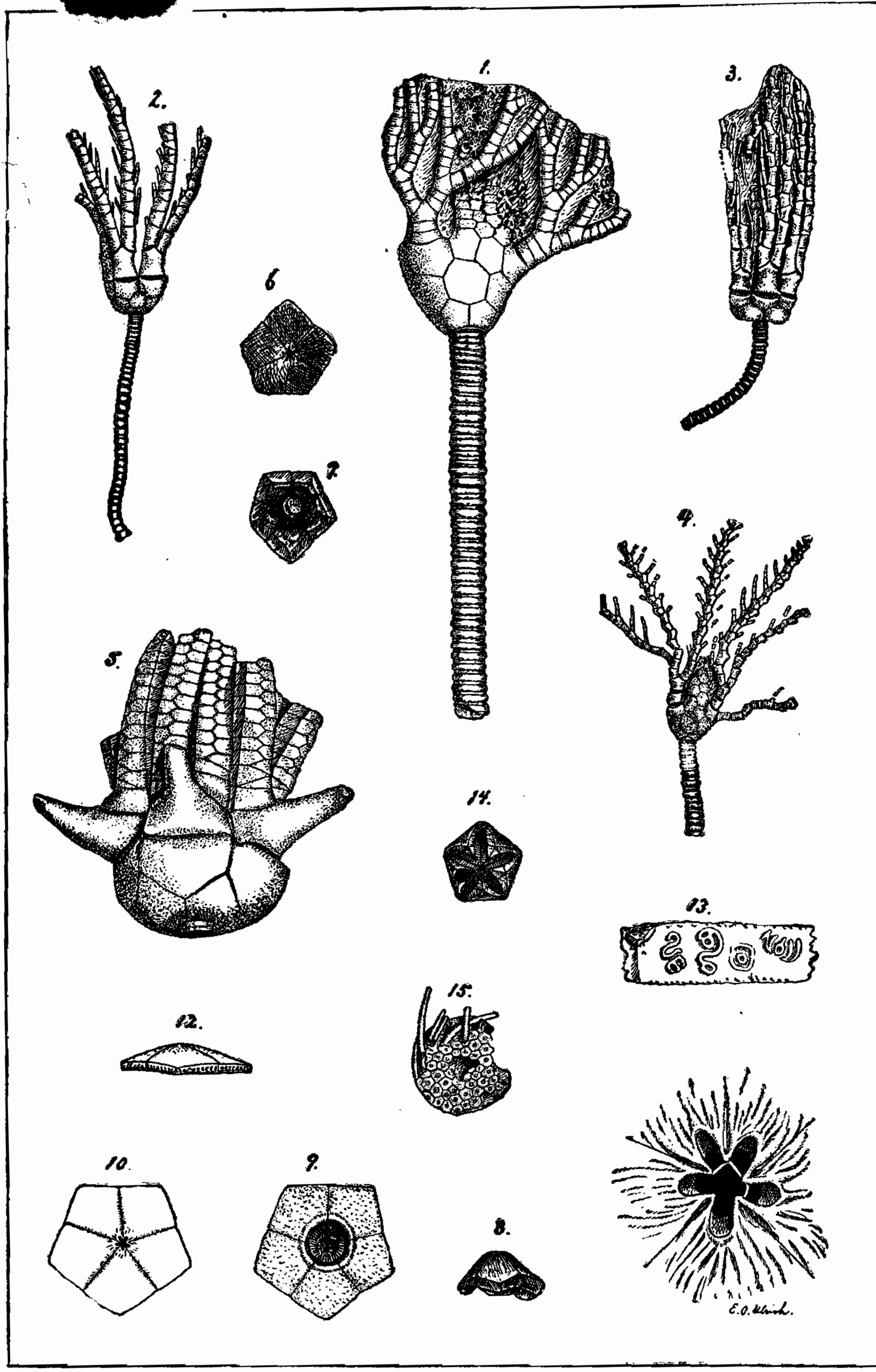
Fig. 15. Natural size.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E. O. Ulrich.

THE WORK.

It is hard to estimate the value of the labors of the Geologists of Indiana in their efforts to acquire and publish the facts concerning the natural resources of the State, and the scientific information connected with the same. All the industries of the State are due to its natural resources; and the existence of valuable lands, minerals or other properties must be known before men can be induced to invest their money or labor in their development.

It was mainly through the efforts of Professors Cox, Collett and Dr. Ryland T. Brown that the value of the immense coal deposits of the State became known to the world, and the same earnest workers first declared and published the value of the oölitic limestone deposits of the State, as well as that of many other valuable varieties of building stone. Professor Thompson, during his administration of the office, continued in the same line and devoted his efforts mainly to the work of developing the natural resources.

To acquire a good, practical, working knowledge of the rock formations of the State, the student must familiarize himself with the organic remains found in the rocks. These consist of the preserved forms of animal or vegetable organisms. So much importance is attached to these fossil remains that in almost every State or National Geological Survey, whenever a species hitherto unknown to science is found, a full description of the same, with figures fully illustrating it is immediately published. These fossils are the characters by which the rocks are read, and whenever they are found in a stratum of rock, the practical Geologist will at once recognize the true position of the rock.

To aid the students of this State in their geological studies, Prof. Collett began in 1880 the publication of full descriptions and figures illustrating the various fossils found in Indiana. This work he continued, as the means at his command would admit, until he retired from the office in 1885. Some of his figures and descriptions were re-publications and others were wholly new. To illustrate the manner in which his work was appreciated, and the value attached to it by scientific men, it is only necessary to state that nearly every one of the new figures prepared by Prof. Collett has recently been reproduced by the Geological Survey of Pennsylvania.

The present State Geologist desires to continue the publication of such discoveries as are wholly new, and connected with the geology or natural history of the State, and he has perfected arrangements by which this work may be done at a moderate cost to the State. This Report, containing ten new plates, and their accompanying matter, will be immediately followed by the Seventeenth Report, which will contain 20 plates and much additional scientific information.

In additional to this valuable palæontological matter by Prof. S. A. Miller, the Seventeenth Report will contain an exhaustive report upon the building stones of the State by Maurice Thompson; the Geology of Steuben and Whitley Counties by Prof. Dryer; the Geology of Cass and Wabash Counties by Dr. Elrod and A. C. Benedict; Reptiles of the State by Prof. O. P. Hay, of Butler University; Butterflies of the State by Prof. Blatchley, of Terre Haute; reports from the Natural Gas, Oil and Mine Inspectors, and much other valuable matter.

THE FLORA OF DEARBORN COUNTY.

The following list of plants embraces such as have been observed in the vicinity of Lawrenceburgh, Indiana, by Dr. S. H. Collins, of that city, well known as a naturalist in Southeastern Indiana. Dr. Collins has taken great pains for several years past to study the plants of that region. This list is a valuable contribution from him, and he promises to add to it such plants as may be observed by him later on:

A partial Flora of Dearborn County, Indiana, and vicinity, *i. e.*, Kentucky shore of the Ohio River, and Ohio shore of the Great Miami River. Classified by S. H. Collins, M. D., Lawrenceburgh, Indiana.

(Authorities—Gray, Coulter and Woods.)

RANUNCULACEÆ.

Clematis Virginiana.
Anemone nemorosa.
Thalictrum anemonoides.
Hepatica triloba.
Vars. { A. acutiloba. / B. obtusiloba.
Ranunculus acris.
R. repens.
R. bulbosus.
R. multifidus.
R. fascicularis.
Delphinium azureum.
D. tricorne.
D. exaltatum.
D. consolida.
Cimicifuga racemosa.
Aquilegia Canadensis.
Hydrastis Canadensis.
Clematis Viorna.

MANGOLIACEÆ.

Liriodendron tulipifera.

MENISPERMACEÆ.

Menispermum Canadense.

ANONACEÆ.

Asimina triloba.

BERBERIDACEÆ.

Jeffersonia diphylla.
Podophyllum peltatum.
Caulophyllum thalictroides.

PAPAVERACEÆ.

Stylophorum diphyllum.
Sanguinaria Canadensis.

FUMARIACEÆ.

Dicentra cucullaria.
D. Canadensis.
Corydalis flavula.

CRUCIFERÆ.

Dentaria diphylla.
D. laciniata.
Arabis hesperidoides.
Capsella Bursa-pastoris.
Lepidium Virginicum.
Brassica sinapistrum.

VIOLACEÆ.

Viola cucullata.
V. pubescens.
V. striata.
V. rotundifolia.
V. lanceolata.
V. pedata, var., bi-color.
V. tri-color, var., arvensis.

CARYOPHYLLACEÆ.

Saponaria officinalis.
Silene Virginica.
Lychnis Githago.
Stellaria media.

TILIACEÆ.

Tilia Americana.

PORTULACACEÆ.

Portulaca oleracea.
Claytonia Virginica.

GERANIACEÆ.

Impatiens pallida.
I. fulva
Geranium Robertianum.
G. maculatum.
Oxalis stricta.
O. acetosella.
O. violaceæ.

RUBIACEÆ.

Cephalanthus occidentalis.
Houstonia cærulea.

DIPSCEÆ.

Dipsacus sylvestris.

COMPOSITÆ.

(The list of plants of this order is very incomplete.)

Vernonia Noveboracensis.
Eupatorium purpureum.
E. perfoliatum.
E. ageratoides.
Ageratum conyzoides.
Solidago cæsia.
S. speciosa.
S. altissima.
Ambrosia trifida.
A. artemisiæfolia.
Rudbeckia laciniata.
Helianthus lætiflorus.
Maruta cotula.
Achillea millefolium.
Leucanthemum-vulgare.
Inula Helenium.
Erechthites hieracifolia.
Cirsium pumilum.
C. lanceolatum.
Lappa officinalis.
Taraxacum Dew-leonis.
Xanthium strumarium.

LOBELIACEÆ.

Lobelia cardinalis.
L. syphilitica.

RUTACEÆ.

Zanthoxylum Americanum.

ANACARDACEÆ.

Rhus glabra.
Rhus toxicodendron.
R. toxicodendron, var., radicans.
R. aromatica.

VITACEÆ.

Vitis cordifolia.
V. Labrusca.
Ampelopsis quinquefolia.

SAPINDACEÆ.

Æsculus flava.
A. glabra.
Acer saccharium.
A. rubum.
A. dasycarpum.
Negundo aceroides.

CELASTRACEÆ.

Euonymus atropurpureus.
Celastrus scandens.

LEGUMINOSÆ.

Trifolium Pratense.
T. repens.
T. agrarium.
Melilotus alba (Nat. introduced from Europe.)
Robinia pseudacacia.
Phaseolus perennis.
Cercis Canadensis.
Cassia Marilandica.
Cleditschia tricanthos.
Gymnocladus Canadensis (rare.)
Lathyrus palustris.
Melilotus officinalis. (Nat. introduced from Europe.)
Trifolium procumbens.
Medicago sativa. (Rather common; from Germany.)
Apios tuberosa.

PRIMULACEÆ.

Dodecatheon Meadia. (Not common.)

VERBENACÆ.

Verbena bracteosa. (Introduced from Illinois in baled hay.)

ROSACEÆ.

Rosa blanda.
R. rubiginosa.
Rubus villosus.
R. occidentalis.
R. strigosus.
Cratægus coccinea.
Cratægus flava.
Fragaria Virginiana.
Potentilla Canadensis.
Spiræa opulifolia (rare.)

SAXIFRAGACEÆ.

Hydrangea arborescens.
Saxifraga Virginiensis.

ONAGRACEÆ.

Œnothera biennis.

CRASSULACEÆ.

Sedum ternatum.

UMBELLIFERÆ.

Pastinaca sativa.
Conium maculatum.
Erigenia bulbosa.

CAPRIFOLIACEÆ.

Sambucus Canadensis.

PLANTAGINACEÆ.

Plantago major.
P. aristata. (Introduced in baled hay from Illinois; has become a pest.)

BIGNONIACEÆ.

Tecoma radicans.
Catalpa bignonioides.

SCROPHULARIACEÆ.

Verbascum thapsus.
Linaria vulgaris.
Collinsia verna.
Scrophularia nodosa.
Verbascum blattaria.
Pentstemon digitalis.

LABIATÆ.

Trichostema dichotomum.
Mentha viridis.
M. Canadensis.
Lamium amplexicaulis.
Collinsonia Canadensis,
Nepeta glechomia.
N. cataria.
Hedeoma pulegioides.
Monarda fistulosa.
Physostegia Virginiana.
Leucas Martinicensis.
Scutellaria pilosa.

AQUIFOLIACEÆ.

Ilex verticillata.

POLEMONACEÆ.

Polemonium reptans.
Phlox pilosa.
Phlox paniculata.

CONVOLVULACEÆ.

Ipomoea purpurea.
I. nil.
I. pandurata.
Convolvulus-arvensis.
Cuscuta arvensis.
C. glomerata.

SALANACEÆ.

Salanum nigrum.
S. dulcamara.
Datura stramonium.
Physalis pubescens.

ASCLEPIADACEÆ.

Asclepias cornuti.
A. tuberosa.

OLEACEÆ.

Fraxinus Americana.
F. quadrangulata.

ARISTOLOCHIACEÆ.

Asarum Canadense.

PHYTOLACCACEÆ.

Phytolacca decandra.

POLYGONACEÆ.

Rumex crispus.
R. obtusifolius.
R. acetosella.
R. altissimus.

LAURACEÆ.

Sassafras officinale.
Lindera benzoin.

LORANTHACEÆ.

Phoradendron flavescens.

URTICACEÆ.

Ulmus flava.
U. Americana.
Ulmus racemosa.
Celtis occidentalis.
Morus rubra.
Urtica gracilis.
U. dioica.

PLANTANACEÆ.

Platanus occidentalis.

CAPPARIDACEÆ.

Polanisia graveolens.

JUNGLANDACEÆ.

Juglans cinerea.
J. nigra.
Carya sulcuta.
C. tomentosa.
C. porcina.
C. alba.

CUPULIFERÆ.

Quercus alba.
Q. prinus.
Q. acuminata. (Var. of prinus (?) Gray.)
Q. rubra.

SALICACEÆ.

Salix viminalis.
S. sericea.
S. longifolia.
Populus tremuloides.
P. monilifera.

MALVACEÆ.

Malva rotundifolia.

ARACEÆ.

Arisæma triphyllum.

ACANTHACEÆ.

Ruellia strepens.

TYPHACEÆ.

Typha latifolia.

IRIDACEÆ.

Iris versicolor.
Sisyrinchium Bermudiana.

SMILACEÆ.

Smilax rotundifolia.

LILIACEÆ.

Trillium sessile.
T. grandifolium.
T. erectum.
T. var., album.
Polygonatum giganteum.
Erythronium Americanum.
E. albidum.
Scilla Fraseri.
Unelaria grandifolia.

ARALIACEÆ.

Aralia quinquefolia.

OROBANCHACEÆ.

Conophalis Americana.

CORNACEÆ.

Nyssa multiflora.
Cornus florida.

HYDROPHYLLACEÆ.

Phacelia Purshii.

COMMELYNACEÆ.

Tradescantia pilosa.

BORAGINACEÆ.

Mertensia Virginica.

LOGONIACEÆ.

Calypremum procembens.

ORCHIDACEÆ.

Cypripedium parviflorum (very rare).
Orchis spectabilis (rare).

The following *Pteridophyta* have been found in Dearborn County, Ind., and vicinity, *i. e.*, the Kentucky shore of the Ohio River, in Boone County, Ky., and the Ohio shore of the Great Miami River, in Hamilton County, O. Practically one field, formerly exceedingly rich in cryptogamous plants, but yearly becoming rapidly less so, by reason of the cutting of trees and ground cultivation thereafter.

ORDER I. EQUISETACEÆ.

Equisetum arvense.
E. hiemale.
E. sylvaticum.

ORDER II. OPHIOGLOSSACEÆ.

Botrychium lunaria.

ORDER III. FILICES.

Adiantum pedatum.
Polypodium vulgare.
Pellæa atropurpurea.
Camptosorus rhizaphyllus.
Onoclea seusibilis.
Pteris aquilina.
Aspidium acrostichoides.
Osmunda regelis.
O. cinnamomea.
Woodsia obtusa.
Dicksonia punctilobula.

LIST OF SPECIMENS IN THE STATE MUSEUM.

After moving the specimens belonging to the State Museum into the new and commodious rooms in the new State House, it was many months before new cases were prepared so that the work of classifying and arranging could begin. Even then work could not be done to advantage for the reason that only a little more than half the necessary cases were furnished, and the work of arranging the specimens in zoological order could not be satisfactorily accomplished. It is the design to procure the remainder of the cases and then proceed with the work of permanently arranging all the specimens and classifying them zoologically. So far it has not been possible to do this and it is not pretended that the following catalogue of specimens is any more than a provisional list. Following the list of specimens in the State Cabinet is a list of duplicates with number of specimens also.

In additiön to the species enumerated, there are yet many others in the collection that have not yet been reached, as there are still about one hundred boxes of fossils and other specimens to sort over, classify and arrange. When this work is done the number of species in the museum will be largely augmented. Besides, the State Geologist has lately acquired by purchase, at a very low price, the large and valuable collection of Niagara fossils made by Drs. F. M. and Warren Howard, at St. Paul, Ind. This collection contains a large number of valuable species hitherto unknown to science.

PLANTÆ.

There are a vast number of Coal Measures and other plant remains in the State collection, embracing many species, but in the work of cleaning, classifying and arranging, they have not yet been reached. It is the design to begin work on these at a very early day.

PROTOZOA.

	No. of Specimens.
Astræospongia hamiltonensis, M. & W., Upper Helderberg Group, Clark Co., Ind.	3
Astylospongia bursa, Hall, Niagara Group, Waldron, Ind	4
A. præmorsa, Hall, Niagara Group, Waldron, Ind.	27
A. stellatim-sulcata, Roemer, Niagara Group, Waldron, Ind	9
A. stellatim-sulcata, Roemer, Niagara Group, Louisville, Ky	6
A. stellatim-sulcata, Roemer, from the Drift, Indianapolis, Ind	1
Endothyra baileyi, Hall, Warsaw Group, Gosport, Ind	1
Eozoon canadense, Dawson, Laurentian Period, Canada	1
Fusulina cylindrica, Fischer, Permian Group, Elk Co., Kan.	3
F. cylindrica, Fischer, Permian Group, Greenwood Co., Kan	1
F. cylindrica, Fischer, Coal Measures, Tecumseh, Neb	1
F. ventricosa, M. & H., Coal Measures, from an Indian Mound in Wisconsin	30
Palæacis obtusus, E. & H., Warsaw Group, Lanesville, Ind.	78
Receptaculites hemisphericus, Hall, Niagara Group, Grant Co., Ind.	6
R. hemisphericus, Hall, Niagara Group, Delphi, Ind	2
R. oweni, Hall, Galena Limestone, Grant Co., Wis	1
R. oweni, Hall, Galena Limestone, Iowa	1
Receptaculities subturbinatus, Hall, Niagara Group, Hartsville, Ind.	1
Stromatopora concentrica, Goldfuss, Niagara Group, Louisville, Ky.	3
S. constellata, Hall (Cœnostroma constellatum), Upper Helderberg Group, Logansport, Ind	1
S. constellata, Hall, See above, Upper Helderberg Group, Falls of the Ohio	1
S. densum, Nicholson (Syringostoma densum), Upper Helderberg Group, Charleston, Ind	1
S. granulata, Nicholson, Upper Helderberg Group, Falls of the Ohio	5
S mammillata, Nicholson, Upper Helberberg Group, Falls of the Ohio	3
S. mammillata, Nicholson, Upper Helderberg Group, Clark Co., Ind.	2
S. mammillata, Nicholson, Upper Helderberg Group, Drift, Delphi, Ind.	1
S. monticulifera, W. & M. (Cœnostroma monticuliferum), Upper Helderberg Group, Falls of the Ohio	1
S. nodulata, Nicholson, Upper Helderberg Group, Clark and Cass Counties, Ind	4
S. nodulata, Nicholson, Upper Helderberg Group, Falls of the Ohio.	2
S. perforata, Nicholson, Upper Helderberg Group, Cass Co., Ind.	25
S. substriatella, Nicholson, Upper Helderberg Group, Falls of the Ohio	1

CŒLENTERATA.

	No. of Specimens.
Acervularia davidsoni, E. & H., Upper Helderberg Group	19
Acrophyllum oneidœnse, Billings, Upper Helderberg Group	10
Agaricia rotata, Goldfuss, Puesseux (Ardennes), France	1
Alveolites constans, Davis, Upper Helderberg Group, Falls of the Ohio	1
A goldfussi, Billings, Upper Helderberg Group, Delphi, Ind . .	1
A. megastoma, Winchell, Upper Helderberg Group, Falls of the Ohio.	1
A. minimus, Davis, Upper Helderberg Group, Falls of the Ohio. .	3
A. mordax, Davis, Upper Helderberg Group, Falls of the Ohio . .	7
A. niagarensis, Rominger, Niagara Group, Louisville, Ky	1
A. rockfordensis, Hall, Chemung Group, Cerro Gordo, Iowa . . .	3
A. squamosus, Billings, Upper Helderberg Group, Falls of the Ohio	3
Alveopora ramosa (?), Michelin, Coralline Bed, Peusseus (Ardenne) France	1
Amplexus coralloides, Sowerby, Warsaw Group, Lanesville, Ind . .	52
A. fragilis, W. & St. J., Keokuk Group, Providence, Ind	12
A. shumardi, Milne-Edwards, Niagara Group, Louisville, Ky . . .	20
A. shumardi, Milne-Edwards, Niagara Group, Charlestown, Ind . .	34
Amplexus, yandelli, E. & H., Upper Helderberg Group, Falls of the Ohio	8
Aulacophyllum sulcatum, D' Orbigny, Hamilton Group, Iowa City, Iowa	1
A. trisculcatum, Hall, Upper Helderberg Group, Charlestown, Ind	2
Aulopora gigas, Rominger, Keokuk Group, Crawfordsville, Ind . .	2
A. gigas, Rominger, Keokuk Group, Fordyce, Ind	6
A. gigas, Rominger, Keokuk Group, Edwardsville, Ind	1
A. gigas, Rominger, Warsaw Group, Lanesville, Ind	25
Baryphyllum d'orbignyi, E. & H., Hamilton Group, Charlestown, Ind	12
Blothrophyllum acuminatum (?), Hall, Upper Helderberg Group, Falls of the Ohio	2
B. approximatum, Nicholson, Upper Helderberg Group, Falls of the Ohio	4
B. decorticatum, Billings, Upper Helderberg Group, Falls of the Ohio	17
B. decorticatum, Billings, Upper Helderberg Group, Sedalia, Mo .	3
B. promissum, Hall, Upper Helderberg Group, Falls of the Ohio .	17
B. sessile, Davis, Upper Helderberg Group, Falls of the Ohio . .	5
B. zaphrentiformis, Davis, Upper Helderberg Group, Clark Co., Ind	9
Casceola attenuata, V. M. Lyon, Niagara Group, Louisville, Ky . .	1
C. tennesseensis, Roemer, Niagara Group, Louisville, Ky	4
Collopora punctata, Hall, St. Louis Group, Lanesville, Ind	2

	No. of Specimens.
Campophyllum nanum, H. & W., Hamilton Group, Floyd Co., Iowa	4
Ceramopora confluens, Hall, Niagara Group, Waldron, Ind	4
Chetetes carbonarius, Worthen, Permo-Carboniferous, Elk Co., Kan.	6
C. furcatus, Hall, Hamilton Group, Cerro Gordo, Iowa.	12
C. milleporaceus, E. & H., Coal Measures, Newburg, Ind.	1
C. milleporaceus, E. & H., Permo-Carboniferous, Greenwood, Co., Kan	1
Chonophyllum magnificum, Billings, Upper Helderberg Group, Falls of the Ohio	2
C. magnificum, Billings, Upper Helderberg Group, Logansport, Ind.	2
C. niagarense, Hall, Niagara Group, Waldron, Ind	1
C. ponderosum, Rominger, Hamilton Group, Charlestown, Ind . . .	1
Cladopora aspera, Rominger, Upper Helderberg Group, Falls of the Ohio	2
C. bifurca, Davis, Upper Helderberg Group, Falls of the Ohio . .	1
C. cryptodens, Billings, Upper Helderberg Group, Falls of the Ohio	4
C. expatiata, Roemer, Upper Helderberg, Falls of the Ohio. . . .	1
C. fisheri, Billings, Upper Helderberg Group, Falls of the Ohio. .	2
C. imbricata, Roemer, Upper Helderberg Group, Falls of the Ohio	2
C. labiosa, Billings, Upper Helderberg Group, Falls of the Ohio .	4
C. laqueata, Roemer, Niagara Group, Louisville, Ky.	1
C. ornata, Roemer, Upper Helderberg Group, Jeffersonville, Ind .	7
C. ornata, Roemer, Hamilton Group, Clark Co., Ind.	7
C. reticulata, Hall, Niagara Group, Louisville, Ky	3
C. robusta, Roemer, Upper Helderberg Group, Falls of the Ohio .	4
C. robusta, Rominger, Upper Helderberg Group, Logansport, Ind .	2
C. verticillata, W. & M., Niagara Group, Louisville, Ky	7
Clisiophyllum conigerum, Rominger, Upper Helderberg Group, Falls of the Ohio	2
Coleophyllum, pyriforme, Hall, Hamilton Group, Falls of the Ohio .	2
C. pyriforme, Hall, Upper Helderberg Group, Columbus, Ohio . .	1
Columnaria, alveolata, Trenton Group, Button Bay Island, Vt. . .	1
Crepidophyllum archiaci, Billings, Upper Helderberg Group, Falls of the Ohio	5
C. archiaci, Billings, Upper Helderberg Group, Newton Co., Ind .	1
C. archiaci, Billings, Upper Helderberg Group, Iowa	8
C. archiaci, Billings, Upper Helderberg Group, Leroy, N. Y . . .	1
C. archiaci, Billings, Upper Helderberg Group, Logansport, Ind. .	1
C. archiaci, Upper Helderberg Group, Charlestown, Ind	2
Cyathophyllum arctifossa, Hall, Upper Helderberg Group, Falls of the Ohio	4
C. brevicorne, Rominger, Upper Helderberg Group, Falls of the Ohio	13

	No. of Specimens.
C. corniculum, Milne-Edwards, Upper Helderberg Group, Falls of the Ohio	3
C. corniculum, Milne-Edwards, Upper Helderberg Group, Charlestown, Ind.	40
C. davidsoni, Milne-Edwards, Upper Helderberg Group, Hartsville, Ind	1
C. gemmatum, Hamilton Group, Bethany, N. Y	1
C geniculatum, Rominger, Upper Helderberg Group, Bartholomew Co., Ind	3
C. greenii, Davis, Upper Helderberg Group, Falls of the Ohio	1
C. houghtoni, Rominger, Upper Helderberg Group, Hartsville, Ind.	1
C. juvene, Rominger, Upper Helderberg Group, Falls of the Ohio.	24
C. juvene, Rominger, Hamilton Group, Independence, Iowa	1
C. œdipus, Davis, Upper Helderberg Group, Falls of the Ohio	9
C. pocillum, Davis, Upper Helderberg Group, Falls of the Ohio.	6
C. radicula, Rominger, Niagara Group, Louisville, Ky	66
C. radicula, Rominger, Niagara Group, Waldron, Ind	10
C. robustum, Hall (name preoccupied, Miller), Hamilton Group, Iowa City, Iowa	1
C. rugosum, E. & H., Upper Helderberg Group, Logansport, Ind.	9
C. rugosum, E. & H., Upper Helderberg Group, Falls of the Ohio	3
C. rugosum, E. & H., Upper Helderberg Group, Clark Co., Ind	8
C. tornatum, Davis, Upper Helderberg Group, Charlestown, Ind.	9
C. validum, Hall, Upper Helderberg Group, Columbus, Ohio.	6
C. validum, Hall, Upper Helderberg Group, Falls of the Ohio	18
C. scyphus, Rominger, Hamilton Group, Charlestown, Ind	7
Cyathophyllum sp., Hamilton Group, Iowa City, Iowa	2
Cystiphyllum americanum, E & H., Upper Helderberg Group, Clark Co., Ind	11
C. americanum, E. & H., Hamilton Group, Bartlett's Mills, Ontario	2
C. americanum, E. & H., Hamilton Group, Johnson Co., Iowa	4
C. americanum, E. & H., Hamilton Group, Independence, Iowa	1
C. americanum, E. & H., Upper Helderberg Group, Woodstock, Ont	2
C. nettlerothi, Davis, Upper Helderberg Group, Louisville, Ky	4
C. niagarense, Hall, Niagara Group, Louisville, Ky	2
C. ohioense, Nicholson, Upper Helderberg Group, Ohio	8
C. squamosum, Nicholson, Upper Helderberg Group, Falls of the Ohio	1
C. sulcatum, Billings, Upper Helderberg Group, Falls of the Ohio	18
C. vesiculosum, Goldfuss, Upper Helderberg Group, Falls of the Ohio and Columbus, Ohio	35
Diphyphyllum arundinaceum, Billings, Upper Helderberg Group, Falls of the Ohio.	

	No. of Specimens.
D. arundinaceum, Billings, Upper Helderberg Group, Logansport, Ind	1
D. apertum, Hall, Upper Helderberg Group, Falls of the Ohio	4
D. cæspitosum, Hall, Niagara Group, Delphi, Ind	13
D. cæspitosum, Hall, Niagara Group, Grant Co , Ind	10
D. colligatum, Billings, Upper Helderberg Group, Falls of the Ohio	4
D. dividuum, Davis, Niagara Group, Louisville, Ky	4
D. huronicum, Rominger, Niagara Group, Charlestown, Ind.	1
D. huronicum, Billings, Niagara Group, Wabash, Ind	2
D. huronicum, Billings, Niagara Group, Louisville, Ky	1
D. stramineum, Billings, Upper Helderberg Group, Logansport, Ind	2
D. stramineum, Billings, Upper Helderberg Group, Falls of the Ohio	15
D. stramineum, Billings, Upper Helderberg Group, N. Y.	2
D. stramineum, Billings, Upper Helderberg Group, Charlestown, Ind.	1
Duncanella borealis, Nicholson, Niagara Group, Hartsville, Ind	100
Eridophyllum rugosum, E. & H., Niagara Group, Louisville, Ky	10
E. strictum, E. & H., Upper Helderberg Group, Falls of the Ohio	1
E. strictum, E. & H., Upper Helderberg Group, Charlostown, Ind	2
Favistella stellata, Hall, Hudson River Group, Fayette Co., Ind	6
F. stellata, Hall, Hudson River Group, Madison, Ind	12
F. stellata, Hall, Hudson River Group, Richmond, Ind	7
Favosites amplissimus, Davis, Upper Helderberg Group, Falls of the Ohio	
F. arbor, Davis, Upper Helderberg Group, Falls of the Ohio	3
F. cariosus, Davis, Upper Helderberg Group, Falls of the Ohio	1
F. cavernosa, Rominger, Upper Helderberg Group, Falls of the Ohio	6
F. canadensis, Billings, Upper Helderberg Group, Falls of the Ohio	5
F. clausus, Rominger, Upper Helderberg Group, Falls of the Ohio	3
F. clelandi, Davis, Upper Helderberg Group, Falls of the Ohio	6
F. cristatus, E. & H., Niagara Group, Louisville, Ky	22
F. cymosus, Davis, Upper Helderberg Group, Falls of the Ohio	18
F. digitatus, Rominger, Hamilton Group, Iowa City, Iowa	6
F. emmonsi, Rominger, Upper Helderberg Group, Falls of the Ohio	3
F. emmonsi, Rominger, Upper Helderberg Group, Charlestown, Ind	13
F. epidermatus, Rominger, Upper Helderberg Group, Charlestown, Ind	5
F. epidermatus, Rominger, Upper Helderberg Group, Falls of the Ohio	5
F. epidermatus, Rominger, Upper Helderberg Group, Bartholomew Co., Ind	1
F. epidermatus, Rominger, Upper Helderberg Group, Genesee Co., N.Y	3

	No. of Specimens.
F. epidermatus, Rominger, Upper Helderberg Group, Logansport, Ind	4
F. favosus, Goldfuss, Niagara Group, Louisville, Ky	4
F. fustiformis, Davis, Upper Helderberg Group, Falls of the Ohio	1
F. forbesi var. occidentalis, Hall, Niagara Group, Waldron, Ind	63
F. hamiltonensis, Rominger, Hamilton Group, Drift, Jasper Co., Ind.	1
F. hamiltonensis, Rominger, Hamilton Group, Iowa City, Iowa	1
F. hamiltonensis, Rominger, Hamilton Group, Bethany, N. Y	1
F. hemisphericus, Y. & S., Upper Helderberg Group, Falls of the Ohio	9
F. hemisphericus, Y. & S., Upper Helderberg Group, Charlestown, Ind	1
F. hemisphericus, Y. & S., Upper Helderberg Group, Logansport, Ind	1
F. hispidus, Rominger, Niagara Group, Delphi, Ind	1
F. limitaris, Rominger, Upper Helderberg Group, Logansport, Ind.	15
F. limitaris, Rominger, Upper Helderberg Group, Falls of the Ohio.	3
F. mundulus, Davis, Upper Helderberg Group, Falls of the Ohio	1
F. niagarensis, Hall, Niagara Group, Waldron, Ind	1
F. niagarensis, Hall, Niagara Group, Charlestown, Ind.	1
F. niagarensis, Hall, Niagara Group, Louisville, Ky.	2
F. nitellus, Winchell, Hamilton Group, Genesee Co., N. Y	1
F. obliquus, Rominger, Niagara Group, Louisville, Ky	1
F. placenta, Rominger, Upper Helderberg Group, Falls of the Ohio.	1
F. pleurodictyoides, Nicholson, Upper Helderberg Group, Charlestown, Ind	1
F. proximus, Davis, Upper Helderberg Group, Falls of the Ohio	2
F. proximus, Davis, Upper Helderberg Group, Columbus, Ohio	3
F. pyrum, Davis, Upper Helderberg Group, Falls of the Ohio	10
F. radiatus, Rominger, Upper Helderberg Group, Falls of the Ohio.	5
F. radiatus, Rominger, Upper Helderberg Group, Hartsville, Ind.	1
F. radiciformis, Rominger, Upper Helderberg Group, Falls of the Ohio	7
F. spinigerus, Hall, Niagara Group, Waldron, Ind	28
F. spongilla, Rominger, Niagara Group, Waldron, Ind.	10
F. tuberosus, Rominger, Upper Helderberg Group, Charlestown, Ind	2
F. tuberosus, Rominger, Upper Helderberg Group, Falls of the Ohio	1
F. tuberosus, Rominger, Upper Helderberg Group, Crab Orchard, Ky.	1
F. tuberosus, Rominger, Upper Helderberg Group, Leroy, N. Y	1
F. turbinatus, Billings, Upper Helderberg Group, Falls of the Ohio.	1
F. venustus, Hall, Niagara Group, Louisville, Ky.	4
F. venustus, Hall, Niagara Group, Delphi, Ind	1

	No. of Specimens.
Fistulipora acervulosa, Rominger, Upper Helderberg Group, Falls of the Ohio	4
Hadrophyllum D' Orbigny, E. & H., Hamilton Group, Clark Co., Ind.	125
Halysites catenulatus, Linn, Niagara Group, Charlestown, Ind . . .	1
H. catenulatus, Linn, Niagara Group, Louisville, Ky	12
H. labyrinthicus, Goldfuss, Niagara Group, Delphi, Ind.	1
Heliophyllum coalitum, Rominger, Upper Helderberg Group, Delphi, Ind.	2
H. coalitum, Rominger, Upper Helderberg Group, Falls of the Ohio	1
H. coalitum, Rominger, Upper Helderberg Group, Drift, Delphi, Ind	1
H. exiguum, Billings, Upper Helderberg Group, Falls of the Ohio .	35
H. gemmatum, Hall, Upper Helderberg Group, Falls of the Ohio .	3
H. gemmiferum, Hall, Upper Helderberg Group, Falls of the Ohio,	3
H. halli, E. & H., Hamilton Group, Genesee Co., N. Y.	4
H. halli, E. & H., Hamilton Group, Bethany, N. Y	6
H. halli(?), E. & H., Germany	1
H. halli, E. & H., Hamilton Group, Crab Orchard, Ky	3
H. halli, E. & H., Upper Helderberg Group, Falls of the Ohio .	10
H. halli, E. & H., Hamilton Group, Bethany, N. Y.	4
H. parvum, Hall, Upper Helderberg Group, Falls of the Ohio . .	16
H. scyphulus, Hall, Upper Helderberg Group, Charlestown, Ind . .	4
H. tenuimurale, Hall, Upper Helderberg Group, Charlestown, Ind.,	4
H. tenuimurale, Hall, Upper Helderberg Group, Falls of the Ohio,	1
Lithodendron dichotomus Goldfuss, Coralline Limestone, Puesseux, France	1
L. musiausiacum, Michelin, Coralline Limestone, Peusseux, France,	1
L. subdichotomus, St. Cassian	1
Lithodendron sp., Coralline Limestone, Puesseux, France.	1
Lithostrotion canadense, Castelnau, St. Louis Group, Monroe Co., Ind.	3
L. canadense, Castelnau, St. Louis Group, Putnam Co., Ind. . . .	1
L. canadense, Castelnau, St. Louis Group, Orange Co., Ind . . .	3
L. microstylum, White, Chouteau Group, Sedalia, Mo	1
L. proliferum, Hall, St. Louis Group, Monroe Co., Ind	1
L. proliferum, Hall, Warsaw Group, Mitchell, Ind	1
L. proliferum, Hall, St. Louis Group, Corydon, Ind.	1
L. proliferum, Hall, St. Louis Group, Lanesville, Ind	11
Lophophyllum gainesi, Davis, Niagara Group, Louisville, Ky . . .	2
L. proliferum, E. & H., Keokuk Group, Jasper Co., Ind	15
Lyellia Americana, E. & H., Niagara Group, Louisville, Ky . . .	1
L. decipiens, Rominger, Niagara Group, Louisville, Ky	1

	No. of Specimens.
L. papillata, Rominger, Niagara Group, Louisville, Ky	1
L. parvituba, Rominger, Niagara Group, Louisville, Ky	8
Madrepora palmata, Miocene, Virginia	1
Manon pisiforme, M., St. Cassian	4
Milleria laminata, Davis, Niagara Group, Louisville, Ky	1
Michelinia clappi, E & H., Upper Helderberg Group, Falls of the Ohio	3
M. clappi, E. & H., Upper Helderberg Group, Leroy Co., N. Y	1
M. convexa, D' Orbigny, Upper Helderberg Group, Falls of the Ohio,	4
M. cylindrica, E. & H., Upper Helderberg Group, Falls of the Ohio	10
M. expansa, White, Chouteau Group, Sedalia, Mo.	2
M. favositoidea, Billings, Upper Helderberg Group, Falls of the Ohio	5
M. insignis, Rominger, Upper Helderberg Group, Falls of the Ohio.	1
M. placenta, White, Chouteau Group, Sedalia, Mo.	3
M. trochiscus, Rominger, Hamilton Group, Bethany, N. Y	4
Monticulipora approximata, Nicholson, Hudson River Group, Madison, Ind.	2
M. altrita, Nicholson, Hudson River Group, Madison, Ind.	1
M. briareus, Nicholson, Hudson River Group, Madison, Ind.	9
M. corticans, Nicholson, Hudson River Group, Richmond, Ind.	1
M. dalii, E. & H., Hudson River Group, Madison, Ind	28
M. discoidea, James, Hudson River Group, Madison, Ind.	14
M. discoidea, James, Hudson River Group, Richmond, Ind	4
M. fibrosa, Goldfuss, Clinton Group, North Vernon, Ind	1
M. filiasa, D' Orbigny, Hudson River Group, Richmond, Ind	11
M. frondosa, D' Orbigny, Hudson River Group, Madison, Ind	9
M. irregularis, D' Orbigny, Hudson River Group, Hamilton County, Ohio	3
M. Jamesi, Nicholson, Hudson River Group, Madison, Ind	2
M. lycoperdon, Say, Hudson River Group, Madison, Ind	2
M. monticula, White, Hamilton Group, Iowa City, Iowa	5
M. ortoni, Hall, Hudson River Group, Madison, Ind.	2
M. papillata, McCoy, Hudson River Group, Richmond, Ind.	2
M. petechialis, Nicholson, Hudson River Group, Richmond, Ind	4
M. petechialis, Nicholson, Hudson River Group, Madison, Ind.	8
M. petropolitanus, Pander, Hudson River Group, Madison, Ind	5
M. pulchella, E. & H., Hudson River Group, Madison, Ind.	2
M. rugosa, Hall, Hudson River Group, Madison, Ind	34
M. subpulchella, Nicholson, Hudson River Group, Madison, Ind	3
M. subpulchella, Nicholson, Hudson River Group, Richmond, Ind	3
Montlivattia dichotama, St. Cassian	3

	No. of Specimens.
Omphyma stokesi, *Rominger*, Niagara Group, Louisville, Ky. . . .	5
O. verrucosa Rafinesque & Clifford, Niagara Group, Louisville, Ky.	21
Palæophyllum divaricans, *Nicholson*, Hudson River Group, Oxford, Ohio	20
P. divaricans, *Nicholson*, Trenton Group, Fisherville, Ky.	5
Pachyphyllum woodmani, *White*, Hamilton Group, Rockford, Iowa .	3
P. woodmani, *White*, Chemung Group, Lime Creek, Iowa	4
Phillipsastrea gigas, *Owen*, Upper Helderberg Group, Charlestown, Ind.	1
P. gigas, *Owen*, Hamilton Group, Solon, Iowa	1
P. verneuili, *E. & H.*, Upper Helderberg Group, Drift, Jasper County, Ind.	1
P. yandelli, *Rominger*, Upper Helderberg Group, Charlestown, Ind.	2
Plasmopora elegans, *Hall*, Niagara Group, Louisville, Ky	8
P. follis, *E. & H.*, Niagara Group, St. Paul, Ind	2
P. follis, *E. & H.*, Niagara Group, Louisville, Ky	30
Protarea papillata, *Davis*, Upper Helderberg Group, Falls of the Ohio	1
P. vetusta, *Hall*, Hudson River Group, Madison, Ind	26
Ptychophyllum coniferem, *Davis*, Upper Helderberg Group, Falls of the Ohio	2
P. knappi, *Hall*, Hamilton Group, Crab Orchard, Ky	6
P. knappi, *Hall*, Hamilton Group, Iowa City, Iowa	2
P. tropœnum, *Davis*, Hamilton Group, Crab Orchard, Ky	1
Stellipora antheloidea, *Hall*, Hudson River Group, Madison, Ind . .	19
S. polystomella, *Nicholson*, Hudson River Group, Green Co., Ohio .	1
Streptelasma crassum, *Hall*, Hudson River Group, Richmond, Ind .	7
S. conulus, *Rominger*, Niagara Group, Louisville, Ky	3
S. corniculum, *Hall*, Hudson River Group, Richmond, Ind	10
S. radicans, *Hall*, Niagara Group, Delaware Co., Ind	2
S. radicans, *Hall*, Niagara Group, Waldron Ind	34
S. spongiaxis, *Rominger*, Niagara Group, Grant Co., Ind	1
S. spongiaxis, *Rominger*, Niagara Group, Hartsville, Ind	2
Striatopora alba, *Davis*, Upper Helderberg Group, Falls of the Ohio	3
Striatopora cavernosa, *Rominger*, Upper Helderberg Group, Falls of the Ohio	3
Strombodes mammillaris, *Owen*, Niagara Group, Charlestown, Ind. .	3
S. pentagonus, *Goldfuss*, Niagara Group, Charlestown, Ind	8
S. pentagonus, *Goldfuss*, Niagara Group, Louisville, Ky	4
S. striatus, *D' Orbigny*, Niagara Group, Louisville, Ky.	12
S. striatus, *D' Orbigny*, Niagara Group, Charlestown, Ind	1
Syringopora hisingeri, *Billings*, Upper Helderberg Group, Falls of the Ohio	2

	No. of Specimens.
S. macfarlii, Billings, Upper Helderberg Group, Falls of the Ohio .	2
S. multattenuata, McChesney, Warsaw Group, Putnam Co., Ind . .	1
S. multattenuata, McChesney, Warsaw Group, Lanesville, Ind . . .	2
S. perelegans, Billings, Upper Helderberg Group, Charlestown, Ind.	1
S. tabulata, E. & H., Upper Helderberg Group, Falls of the Ohio.	2
S. tubiporoides, Y. & S., Upper Helderberg Group, Falls of the Ohio	5
Tetradium fibratum, Safford, Hudson River Group, Madison, Ind. .	4
T. fibratum, Safford, Hudson River Group, Richmond, Ind	2
T. fibratum var. minus, Safford, Hudson River Group, Madison, Ind	1
Thecia major, Rominger, Niagara Group, Louisville, Ky	2
T. minor, Rominger, Niagara Group, Louisville, Ky.	6
T. ramosa, Rominger, Upper Helderberg Group, Falls of the Ohio	6
T. swindernana, Goldfuss, Niagara Group, Louisville, Ky	1
Tremaiopora varia, Hall, Niagara Group, Louisville, Ky	3
Zaphrentis bilateralis, Hall, Clinton Group, Madison, Ind	1
Z. convoluta, Hall, Upper Helderberg Group, Falls of the Ohio . .	3
Z. cornicula, Lesueur, Upper Helderberg Group, Charlestown, Ind	14
Z. dalei, E. & H., Keokuk Group, Russellville, Ind	15
Z. davisana, S. A. Miller, Upper Helderberg Group, Falls of the Ohio	6
Z. davisana, S. A. Miller, Upper Helderberg Group, Charlestown, Ind	4
Z. duplicatata, Hall, Upper Helderberg Group, Falls of the Ohio .	1
Z. dawsoni, Whitfield, Keokuk Group, Crawfordsville, Ind	1
Z. elegans, Hall, Upper Helderberg Group, Columbus, Ohio . . .	4
Z. elegans, Hall, Upper Helderberg Group, Falls of the Ohio . .	41
Z. exiguum, Billings, Upper Helderberg Group, Falls of the Ohio .	5
Z. foliata, Hall, Upper Helderberg Group, Falls of the Ohio . . .	7
Z. gigantea, Rafinesque, Upper Helderberg Group, Falls of the Ohio	20
Z. glans, White, Burlington Group, Burlington, Iowa	1
Z. greenana, Davis, Upper Helderberg Group, Falls of the Ohio .	1
Z. herzeri, Hall, Upper Helderberg Group, Charlestown, Ind. . .	3
Z. nitida, Hall, Upper Helderburg Group, Falls of the Ohio . . .	4
Z. profunda, Hall, Upper Helderberg Group, Falls of the Ohio .	7
Z. prolifica, Billings, Upper Helderberg Group, Columbus, O . .	1
Z. prolifica, Billings, Upper Helderberg Group, Falls of the Ohio .	13
Z. rafinesquii, E. & H., Upper Helderberg Group, Falls of the Ohio	11
Z. solida, Hall, Chemung Group, Lime Creek, Iowa	2
Z. spinulifera, Hall, Warsaw Group, Lanesville, Ind	50
Z. spinulifera, Hall, St. Louis Group, Rockhaven, Ky	15
Z. spinulifera, Hall, St. Louis Group, Pella, Iowa	1
Z. spinulosa, E. & H., St. Louis Group, Orange Co., Ind	8

	No. of Specimens.
Z. spinulosa, E. & H., Chester Group, Leavenworth, Ind	30
Z. spissa, Hall, Upper Helderberg Group, Falls of the Ohio . . .	1
Z. stokesi, E. & H., Niagara Group, Grant Co., Ind	2
Z. ungula, Rominger, Upper Helderberg Group, Falls of the Ohio	26
Z. unica, Davis, Upper Helderberg Group, Falls of the Ohio . . .	5
Z. yandelli, Hall, Upper Helderberg Group, Falls of the Ohio . .	4
Z yandelli, Hall, Upper Helderberg Group, Falls of the Ohio . .	8

ECHINODERMATA.

Actinocrinus lowii, Hall, Keokuk Group, Washington and Monroe Counties, Ind	4
A. multiradiatus, Shumard, Burlington Group, Burlington, Iowa. .	2
A. pernodosus, Hall, Keokuk Group, Crawfordsville, Ind.	2
A. proboscidialis, Hall, Burlington Group, Burlington, Iowa . . .	1
A sp., Keokuk Group, Rockhaven, Ky	1
A. sp., Upper Helderberg Group, Falls of the Ohio	2
A. sp., Burlington Group, Burlington, Iowa	
A. sp., Burlington, Group, Curryville, Mo.	2
Agaricocrinus, sp., showing basals, first radials and interradial plates, Keokuk Group, Crawfordsville, Ind	1
A. stellatus, Hall, Burlington Group, Louisiana, Mo.	2
A. wortheni, Hall, Keokuk Group, Washington Co., Ind.	1
Agassizocrinus conicus, O. & S., Kaskaskia Group, Wolf Creek, Ky.	1
A. dactyliformis, Troost, Kaskaskia Group, Chester, Ill	6
A. globosus, Worthen, Kaskaskia Group, Chester, Ill	2
A. pentagonus, Worthen, St. Louis Group, Orange Co., Ind. . . .	6
Agelacrinus cincinnatiensis, Roemer, Hudson River Group, Cincinnati, Ohio	3
Alloprosallocrinus conicus, C. & L., Warsaw Group, Lanesville, Ind.,	6
Amphoracrinus spinobrachiatus, Hall, Burlington Group, Burlington, Iowa	1
A. viminalis (?), Hall, Keokuk Group, Fountain Co., Ind	3
Ancyrocrinus bulbosus, Hall, Upper Helderberg Group, Charlestown, Ind.	19
Ancyrocrinus bulbosus, Hall, Upper Helderberg Group, Falls of the Ohio	16
Archæocidaris keokuk, Hall, Keokuk Group, Bono, Ind.	5
A. norwoodi, Hall, Kaskaskia Group, Orange Co., Ind.	4
A. wortheni, Hall, 65 plates, 48 spines; St. Louis Group, Lanesville, Ind	
Barycrinus herculeus, M. & W., Keokuk Group, Crawfordsville, Ind.	1

	No. of Specimens.
B. magister, *Hall*, Keokuk Group, Lanesville, Ind	1
B. pentagonus, *Worthen*, Keokuk Group, Crawfordsville, Ind	2
B. stellatus, *Troost*, Keokuk Group, Crawfordsville, Ind	4
B. tumidus, *Hall*, Keokuk Group, Monroe Co., Ind	1
Batocrinus æqualis, *Hall*, Keokuk Group, Smithville, Ind	3
B. biturbinatus, *Hall*, Keokuk Group, Bono, Ind	9
B. caroli, *Hall*, Warsaw Group, Lanesville, Ind	2
B. christyi, *Shumard*, Burlington Group, Burlington, Iowa, and Louisiana, Mo	3
B. icosidactylus, *L. & C.*, Warsaw Group, Washington Co., Ind.	9
B. indianensis, *L. & C.*, Keokuk Group, Crawfordsville, Ind	33
B. irregularis, *Casseday*, Warsaw Group, Spergen Hill, Ind.	3
B. lagunculus, *Hall*, Keokuk Group, Smithville, Ind.	2
B. mundulus, *Hall*, Keokuk Group, Edwardsville, Ind.	1
B. nashvillæ, *Hall*, Keokuk Group, Crawfordsville, Ind	9
B. planodiscus (?), *Hall*, Keokuk Group, Bono, Ind	1
B. pyriformis, *Shumard*, Burlington Group, Burlington, Iowa	1
B. rotundus, *Shumard*, Burlington Group, Burlington, Iowa	36
B. whitii, *Wachsmuth & Springer*, Keokuk Group, Bono, Ind	5
Calceocrinus plates, Keokuk Group, Ky	3
C. plates, Upper Coal Measures, Fayette Co., Ill	6
Caryocrinus ornatus, *Say*, Niagara Group, Peru, Delphi and Clark Counties, Ind	12
Catillocrinus bradleyi, *M. & W.*, Keokuk Group, Crawfordsville, Ind.	2
Cyathocrinus arboreus, *M. & W.*, Keokuk Group, Crawfordsville, Ind	10
C. multibrachiatus, *L. & C.*, Keokuk Group, Crawfordsville, Ind.	4
C. polyxo, *Hall*, Niagara Group, Waldron and Hartsville, Ind.	15
C. poterium, *M. & W.*, Keokuk Group, Crawfordsville, Ind	1
C. nucleus, *Hall*, Niagara Group, Waldron, Ind.	1
Dendrocrinus polydactylus, *Shumard*, Hudson River Group, Clinton Co., Ohio	1
D. polydactylus, *Shumard*, Hudison River Group, Madison, Ind	1
D. polydactylus, *Shumard*, Hudson River Group, Franklin Co., Ind.	3
Dichocrinus expansus, *M. & W.*, Keokuk Group, Crawfordsville, Ind	5
D. ficus, *C. & L.*, Keokuk Group, Edwardsville, Ind	2
D. ficus, *C. & L.*, Keokuk Group, Crawfordsville, Ind.	5
D. sculptus, *C. & L.*, Keokuk Group, Monroe Co., Ind.	2
D. simplex, *Shumard*, Warsaw Group, Lanesville, Ind	1
Dorycrinus gouldi, *Hall*, Keokuk Group, Washington Co., Ind	1
D. symmetricus, *Hall*, Burlington Group, Louisiana, Mo	4
D. symmetricus, *Hall*, Burlington Group, Burlington, Iowa	3

	No. of Specimens
D. unicornis, O. & S., Burlington Group, Burlington, Iowa . . .	1
D. spines, possibly those of Dorycrinus præcursor, Hall, Corniferous Group, Lewis Hill, Clark Co., Ind	
Ectenocrinus simplex, Hall, Hudson River Group, Cincinnati, O. .	1
E. simplex, Hall, Hudson River Group, Madison, Ind	4
Encrinus lilliformis, Schlotheim, St. Cassian	9
Eretmocrinus sp., Keokuk Group, Bono, Ind	1
E. verneuilanus, Shumard, Burlington Group, Burlington, Iowa . .	40
E. verneuilanus, Shumard, Burlington Group, Louisiana, Mo . . .	5
E. ramulosus, Hall, Keokuk Group, Unionville, Ind.	5
Eucalyptocrinus cœlatus, Hall, Niagara Group, Hartsville, Ind. . .	2
E. cœlatus, Hall, Niagara Group, Waldron, Ind.	19
E. cœlatus Hall, Basal plates, Waldron, Ind	2
E. crassus, Hall, Niagara Group, Waldron, Ind	24
E. crassus, Hall, Vault plates, Waldron, Ind.	21
E. crassus, Hall, showing interbrachial plates and arms, Waldron, Ind.	6
E. crassus, Hall, Basal and first radial plates, Waldron, Ind . . .	2
E. elrodi, Gorby, Niagara Group, Waldron, Ind.	9
E. ovalis, Troost, Niagara Group, Waldron, Ind.	18
E. splendidus, Troost, Niagara Group, Charlestown, Ind	3
Eugeniacrinus caryophyllatus, Goldfuss, Jura, Wurtenberg, Germany	2
Glyptaster inornatus, Hall, Niagara Group, Waldron, Ind	10
G. occidentalis, Hall, Niagara Group, Waldron, Ind	5
Glyptocrinus decadactylus, Hall, Hudson River Group, Cincinnati, Ohio	6
G. dyeri, Meek, Hudson River Group, Madison, Ind.	4
Goniasteroidocrinus tuberosus, L. & C., Keokuk Group, Crawfordsville, Ind	10
Granatocrinus norwoodi, O. & S., Burlington Group, Burlington, Iowa	11
G. pisum, M. & W., Burlington Group, Curryville, Mo	5
Heterocrinus heterodactylus, Hall, Hudson River Group, Cincinnati, Ohio	2
Holaster elegans, Shumard, Cretaceous, Ft. Worth, Texas	1
Holocystites abnormis, Hall, Niagara Group, Madison, Ind. . . .	1
H. cylindricus, Hall, Niagara Group, Madison, Ind	2
H. pustulosus, S. A. Miller, Niagara Group, Madison, Ind	1
H. ovatus, Hall, Niagara Group, Madison, Ind	7
Ichthyocrinus lævis, Conrad, Niagara Group, Pullman, Ill.	2
I. pucillus (?), Hall, Niagara Group, Waldron, Ind.	1
I. simplex, Hall, Niagara Group, Waldron, Ind.	3
Iocrinus subcrassus, M. & W., Hudson River Group, large slab . .	33

	No. of Specimens.
I. subcrassus, M. & W., Hudson River Group, Cincinnati, O	3
Lampterocrinus inflatus, Hall, Niagara Group, Perry County, Tenn.	1
Lecanocrinus pusillus, Hall, Niagara Group, Waldron, Ind	14
Lichenocrinus crateriformis, Hall, Hudson River Group, Cincinnati, Ohio	1
L. dyeri, Hall, Hudson River Group, Cincinnati, Ohio.	1
Lyriocrinus melissa, Hall, Niagara Group, Waldron, Ind	27
Lysocystites nodosus, Hall, Niagara Group, Madison Ind.	1
Macrostylocrinus fasciatus, Hall, Niagara Group, Waldron, Ind.	2
M. ornatus, Hall, Niagara Group, Waldron, Ind	1
M. striatus, Hall, Niagara Group, Waldron, Ind	3
M. striatus var. granulosus, Hall, Niagara Group, Waldron, Ind	1
Mariacrinis obconicus, Hall, Niagara Group, Waldron, Ind., and Clark Co., Ind.	7
Marsupiocrinus tennesseensis, Roemer, Niagara Group, Delphi, Ind	2
Megistocrinus rugosus, L. & C., Upper Helderberg Group, Falls of the Ohio	2
M. evansi, O. & S., Burlington Group, Burlington, Iowa.	1
Melonites multiporus, O. & N., large slab, St. Louis Group, St. Louis, Mo., on slab	16
Neucleocrinus verneuili, Troost, Upper Helderberg, Group, Columbus, Ohio	4
Neucleocrinus verneuili, Troost, Upper Helderberg Group, Falls of the Ohio	14
Ohiocrinus laxus, Hall, Hudson River Group, Madison, Ind.	1
Oligoporus danæ, M. &. W., Keokuk Group, Lawrence Co., Ind.	2
O. nobilis, M. &. W., Keokuk Group, Edwardsville, Ind.	1
Onychocrinus exculptus, L. & C., Keokuk Group, Crawfordsville, Ind	6
O. ramulosus, L. & C., Keokuk Group, Crawfordsville, Ind	3
Pentremites burlingtonensis, M. & W., Burlington Group, Burlington, Iowa	4
P. calycinus, Lyon, St. Louis Group, Orange Co., Ind	20
P. cervinus, Hall, St. Louis Group, Orange Co., Ind	14
P. cherokeus, Troost, Chester Group, Orange Co., Ind	4
P. conoideus, Hall, St. Louis Group, Lanesville, Ind	230
P. conoideus, Hall, Warsaw Group, Harristown, Ind.	150
P. globosus, Troost, St. Louis Group, Orange Co., Ind	4
P. godoni, DeFrance, Kaskaskia Group, Meade Co., Ky	68
P. godoni, DeFrance, St. Louis Group, Orange Co., Ind	21
P. godoni, DeFrance, Chester Group, Orange Co., Ind.	6
P. koninckiana, Hall, Warsaw Group, Lanesville, Ind	35
P. laterniformis, O. & S., Warsaw Group, Bedford, Ind	50
P. laterniformis, O. & S., St. Louis Group, Harristown, Ind	6

	No. of Specimens.
P. obesus, Say, St. Louis Group, Orange Co., Ind	3
P. pyriformis, Say, Locality unknown	2
P. pyriformis, Say, Kaskaskia Group, Chester, Ill	2
P. pyriformis, Say, Chester Group, French Lick, Ind	12
P. sulcatus, Roemer, St. Louis Group, Orange Co., Ind	6
P. symmetricus, Hall, St. Louis Group, Orange Co., Ind	2
P. symmetricus, Hall, Chester Group, Sandstone, Orange Co., Ind	1
Pentremites columus, Permo-Carboniferous, Fredonia, Kan	2
Physetocrinus ventricosus, Meek & Worthen, Burlington Group, Burton, Iowa	2
Platycrinus bonoensis, White, Keokuk Group, Bono, Ind	13
P. discoideus, O. & S., Burlington Group, Burlington, Iowa . . .	1
P. hemisphericus, M. & W., Keokuk Group, Crawfordsville, Ind .	15
P. leai, Lyon, Lower Helderberg Group, Jeffersonville, Ind . . .	1
P. pileiformis, Hall, Burlington Group, Burlington, Iowa	2
P. planus, O. & S., Burlington Group, Burlington, Iowa	2
P. saræ, Hall, St. Louis Group, Lanesville, Ind	31
P. siluricus, Hall, Niagara Group, Waldron, Ind	3
P. yandelli, O. & S., Burlington Group, Burlington, Iowa	1
Pisocrinus gemmiformis, S. A. Miller, Niagara Group, St. Paul, Ind	10
P. globosus, Ringueberg, Niagara Group, St. Paul, Ind	10
P. n. s., Niagara Group, Marion, Ind	12
Poteriocrinus coreyi, Worthen, Keokuk Group, Crawfordsville, Ind.	7
P. hoveyi, Worthen, Keokuk Group, Crawfordsville, Ind	3
P. indianencis, M. & W., Keokuk Group, Crawfordsville, Ind . .	1
P. penicilliformis, Worthen, Keokuk Group, Crawfordsville, Ind .	1
P. penicilliformis (?), *Worthen*, Keokuk Group, Crawfordsville, Ind	1
Pterotocrinus capitalis, Lyon, Kaskaskia Group, Crittenden, Co., Ky	2
Saccocrinus christyi, Hall, Niagara Group, Waldron, Ind	3
S. ornatus, H. & M, Niagara Group, Piqua, O	1
Scaphiocrinus æqualis, Hall, Keokuk Group, Crawfordsville, Ind .	13
S. coreyi, M. & W., Keokuk Group, Crawfordsville, Ind	3
S. decadactylus, M. & W., Keokuk Group, Crawfordsville, Ind . .	1
S. gibsoni, White, Keokuk Group, Crawfordsville, Ind	1
S. gurleyi, White, Keokuk Group, Crawfordsville, Ind	5
S. robustus, Hall, Keokuk Group, Rockhaven, Ky	3
S. unicus, Hall, Keokuk Group, Crawfordsville, Ind	8
S. hoveyi, M. & W	1
S. depressus, M. & W	6
Schizoblastus melonoides, M. & W., Burlington Group, Louisiana, Mo.,	4
Strotocrinus asperrimus, M. & W., Burlington Group, Burlington, Iowa	4
S. ectypus, M. & W., Burlington Group, Burlington, Iowa	2

	No. of Specimens.
S. perumbrosus, *Hall*, Burlington Group, Burlington, Iowa	2
Strotocrinus sp., *Hall*, Burlington, Group, Burlington, Iowa . . .	1
S. sp., Burlington Group, Burlington, Iowa	1
Synbathocrinus swallovi, *Hall*, St. Louis Group, Smithville, Monroe Co., Ind	16
S. robustus, *Shumard*, Keokuk Group, Rockhaven, Ky.	8
S. sp., Keokuk Group, Washington Co., Ind.	1
Talarocrinus cornigerus, *Shumard*, Kaskaskia Group, Harrison Co., Ind.	2
T. sexlobatus, *Shumard*, Kaskaskia Group, Harrison Co., Ind . . .	2
T. sexlobatus, *Shumard*, St. Louis Group, Crawford Co., Ind . . .	8
Taxocrinus Meeki, *Hall*, Keokuk Group, Crawfordsville, Ind . . .	3
T. multibrachiatus, *L. & C.*, Keokuk Group, Crawfordsville, Ind. .	8
T. multibrachiatus var. colletti, *White*, Keokuk Group, Crawfordsville, Ind	5
T. ramulosus, *Hall*, Keokuk Group, Crawfordsville, Ind	3
Tricœlocrinus varsouviensis, *Worthen*, Warsaw Group, Bloomington, Ind.	2
T. woodmani, *M. & W.*, Keokuk Group, Putnam Co., Ind	8
Troostocrinus wortheni, *Hall*, Keokuk Group, Edwardsville, Ind . .	1
Vasocrinus lyoni, *Hall*, Keokuk Group, Crawfordsville, Ind. . . .	3
Zeacrinus maniformis, *Y. & S.*, Kaskaskia Group, Harrison Co., Ind.,	3
Z. sp., St. Louis Group, Milltown, Ind	1

MOLLUSCOIDA.

Archimedes laxus, *Hall*, Kaskaskia Group, Harrison Co., Ind . . .	168
A. meekanus, *Hall*, Kaskaskia Group, Orange Co., Ind.	10
A. meekanus, *Hall*, St. Louis Group, Orange Co., Ind	84
A. owenanus, *Hall*, Keokuk Group, Crawfordsville, Ind.	3
A. reversus, *Hall*, Kaskaskia Group, Wolf Creek, Ky.	10
A. reversus, *Hall*, Kaskaskia Group, Orange Co., Ind	2
A. swallovanus, *Hall*, Kaskaskia Group, Wolf Creek, Ky.	7
A. wortheni, *Hall*, Kaskaskia Group, Orange Co., Ind	1
Coscinium asterium, *Prout*, Warsaw Group, Lanesville, Ind	2
C. escharoides, *Prout*, Keokuk Group, Edwardsville, Ind	4
C. michelini, *Prout*, Warsaw Group, Lanesville, Ind.	26
C. wortheni, *Prout*, Keokuk Group, Edwardsville, Ind.	1
Cyclopora discoidea, *Prout*, St Louis Group, Lanesville, Ind. . . .	15
Fenestella delicata, *Meek*, Kaskaskia Group, Union Co., Ill.	1
F. delicata, *Meek*, Keokuk Group, Edwardsville, Ind	1
F. parvulipora, *Hall*, Niagara Group, Waldron, Ind	7
F. prisca, *Lonsdale*, Kaskaskia Group, Union Co., Ill	1

	No. of Specimens.
Lichenalia concentrica, Hall, Niagara Group, Waldron, Ind	18
L. maculata, Hall, Niagara Group, Waldron, Ind	2
Polypora stragula, White, Coal Measures, Dubois Co., Ind	1
Polypora submarginata, Meek, Coal Measures, Dubois Co., Ind. . .	4
Ptilodictya hilli, James, Hudson River Group, Garrard Co., Ky . .	1
Rhombopora lepidodendroidea, Meek, Permo-Carboniferous, Grenola, Kan	12
Stomatopora auloporoides, Nicholson, Hudson River Group, Oxford,	1
Ohio	1
S. auloporoides, Nicholson, Hudson River Group, Richmond, Ind. .	1
S. frondosa, James, Hudson River Group, Madison, Ind	1
S. inflata, Hall, Hudson River Group, Madison, Ind.	1
Subretepora angulata, Hall, Niagara Group, Delaware Co., Ind . .	1
S. clathrata, Miller & Dyer, Hudson River Group, Garrard Co., Ky	1
Trematopora minuta, Hall, Niagara Group, Waldron, Ind	1

BRACHIOPODA.

Ambocœlia umbonata, Conrad, Hamilton Group, Cayuga Lake, N. Y.	5
Anastrophia verneuili, Hall, Niagara Group, Waldron, Ind	125
Athyris hirsuta, Hall, Warsaw Group, Lanesville, Ind	142
A. lamellosa, Leveille, Chester Group, Orange County, Ind	9
A. lamellosa, Leveille, Keokuk Group, Alters, Ind.	18
A. lamellosa Leveille, Warsaw Group, Lanesville, Ind	106
A. sublamellosa, Hall, Kaskaskia Group, Meade County, Ky . . .	115
A. subquadrata, Hall, St. Louis Group, Pella, Iowa	10
A. subquadrata, Hall, Kaskaskia Group, Meade County, Ky . . .	136
A. subquadrata, Hall, Chester Group, Orange County, Ind	42
A. subtilita, Hall, Coal Measures, Vigo County, Ind.	29
A. subtilita, Hall, Permo-Carboniferous, Elk County, Kas	7
A. spiriferoides, Eaton, Hamilton Group, Bethany, N. Y.	21
A. spiriferoides, Eaton, Upper Helderberg Group, Charlestown, Ind.	8
A. trinuclea, Hall, St. Louis Group, Greencastle, Ind	9
A. trinuclea, Hall, Warsaw Group, Lanesville, Ind	210
A. vittata, Hall, Upper Helderberg Group, Clark County, Ind . .	60
Atrypa aspera, Schlotheim, Upper Helderberg Group, Charlestown, Ind.	3
A. aspera, Schlotheim, Upper Helderberg Group, Columbus, O . .	7
A. aspera var. occidentalis, Hall, Chemung Group, Columbus, O . .	16
A. hystrix, Hall, Chemung Group, Rockford, Ia.	11
A. hystrix, Hall, Hamilton Group, Iowa City, Ia	15
A. reticularis, Linnæus, Hamilton Group, Rockford, Ia.	13
A. reticularis, Upper Helderberg Group, Falls of the Ohio	22

	No. of Specimens.
A. reticularis, Niagara Group, Waldron, Ind	101
Camarophoria subtrigona, *M. & W.*, Keokuk Group, Crawfordsville, Ind.	3
Chonetes fischeri, *N. & P.*, Knobstone Group, Montgomery County, Ind.	2
C. glaber, *Hall*, Upper Coal Measures, Pleasant Hill, Mo.	1
C. granuliferus, *Owen*, Coal Measures, Vigo County, Ind.	3
C. granuliferus, *Owen*, Permo-Carboniferous, Cottonwood Falls, Kas.	5
C. lepidus, *Hall*, Hamilton Group, Lexington, Ind	4
C. mesolobus, *N. & P.*, Coal Measures, Knob Knoster, Mo	6
C. mesolobus, *N. & P.*, Upper Coal Measures, Pleasant Hill, Mo. .	5
C. planumbonus, *M. & W.*, Knobstone Group, New Providence, Ind	1
C. planumbonus, *M. & W.*, Keokuk Group, Alters, Ind	16
C. planumbonus, *M. & W.*, Keokuk Group, Clark County, Ind. . .	12
C. scitulus, *Hall*, Hamilton Group, Bethany, N. Y	1
C. scitulus, *Hall*, Hamilton Group, Erie County, N. Y	3
C. yandellanus, *Hall*, Upper Helderberg Group, Clark County, Ind.	44
Cœlospira disparilis, *Hall*, Niagara Group, Waldron, Ind.	1
Crania lœlia, *Hall*, Hudson River Group, Cincinnati, O	1
C. scabiosa, *Hall*, Hudson River Group, Cincinnati, O	2
C. scabiosa, *Hall*, Hudson River Group, Cincinnati, O	5
C. setifera, *Hall*, Niagara Group, Waldron, Ind	5
C. siluriana, *Hall*, Niagara Group, Waldron, Ind	1
Cyrtina acutirostris, *Shumard*, Kinderhook Group, Louisiana, Mo. .	3
C. hamiltonensis, *Hall*, Hamilton and Upper Helderberg Groups, Clark Co., Ind.	36
Discina ampla, *Hall*, Upper Helderberg Group, Charlestown, Ind.	3
D. convexa, *Shumard*, Coal Measures, Dubois Co., Ind	2
D. grandis, *Hall*, Upper Helderberg Group, Charlestown, Ind. . .	2
D. media, *Hall*, Hamilton Group, Buffalo, N. Y.	3
D. newberryi, *Hall*, Hamilton Group, Buffalo, N. Y	1
D. nitida, *Phillips*, Coal Measures, Ill	1
D. seneca, *Hall*, Upper Helderberg Group, Charlestown, Ind. . .	1
D. seneca, *Hall*, Upper Helderberg Group, Charlestown, Ind. . .	1
Eichwaldia reticulata, *Hall*, Niagara Group, Waldron, Ind	58
Leiorhynchus limitare, *Vanuxem*, Marcellus Shale, Union Springs, N. Y.	2
L. quadricostatum, *Vanuxem*, Hamilton Group, Lexington, Ind. . .	18
Leptœna sericea, *Sowerby*, Hudson River Group, Richmond, Ind . .	35
Lingula quadrata, *Eichwald*, Trenton Group, Dubuque, Iowa . . .	6
L. spatulata, *Vanuxem*, Genesee Shale, Chagrin Falls, Ohio	5
Meekella striato-costata, *Cox*, Permo-Carboniferous, Greenwood Co., Kan	4

	No. of Specimens.
Meristella haskinsi, *Hall*, Upper Helderberg Group, Charlestown, Ind	3
M. nasuta, *Conrad*, Upper Helderberg Group, Falls of the Ohio	1
M. unisulcata, *Conrad*, Upper Helderberg Group, Charlestown, Ind.,	17
M. unisulcata, *Conrad*, Upper Helderberg Group, Falls of the Ohio,	4
Meristina nitida, *Hall*, Niagara Group, Waldron, Ind.	100
Nucleospira pisiformis, *Hall*, Niagara Group, Waldron, Ind	46
Orthis acutilirata, *Conrad*, Hudson River Group, Madison, Ind.	33
O. bellula, *Meek*, Hudson River Group, Cincinnati, Ohio	6
O. biforata, *Schlotheim*, Hudson River Group, Madison, Ind	46
O. biloba, *Linn*, Niagara Group, Walcott, N. Y.	2
O. borealis, *Billings*, Hudson River Group, Madison, Ind	20
O. centrosa, *S. A. Miller*, Hudson River Group, Madison, Ind	17
O. crassa, see *O. centrosa*.	
O. dentata, *Pander*, Hudson River Group, Madison, Ind	18
O. dubia Hall, St. Louis Group, Harristown, Ind	48
O. elegantula, *Dalman*, Niagara Group, Waldron, Ind	20
O. ella, *Hall*, Hudson River Group, Cincinnati, Ohio.	4
O. emacerata, *Hall*, Hudson River Group, Madison, Ind	8
O. fissicosta, *Hall*, Hudson River Group, Madison, Ind	2
O. hybrida, *Sowerby*, Niagara Group, Waldron, Ind	72
O. impressa, *Hall*, Hamilton Group, Iowa City, Iowa.	10
O. insculpta, *Hall*, Hudson River Group, Madison, Ind	8
O. iowensis, *Hall*, Upper Helderberg Group, Charlestown, Ind.	10
O. keokuk, *Hall*, Keokuk Group, Smithville, Ind	2
O. laticosta, *Meek*, Hudson River Group, Madison, Ind	36
O. leucosia, *Hall*, Upper Helderberg Group, Charlestown, Ind	3
O. livia, *Billings*, Upper Helderberg Group, Charlestown, Ind	20
O. lynx, *Eichwald*, Hudson River Group, Madison, Ind.	25
O. meeki, *S. A. Miller*, Hudson River Group, Cincinnati, Ohio	11
O. michelini, *L'Eveille*, Keokuk Group, Jasper Co., Ind	20
O. michelini var. burlingtonensis, *Hall*, Knobstone Group, Providence, Ind.	21
O. michelini var. burlingtonensis, *Hall*, Burlington Group, Louisiana, Mo.	3
O. occidetalis, *Hall*, Hudson River Group, Madison, Ind	28
O. plicatella, *Hall*, Hudson River Group, Madison, Ind.	3
O. proprinqua, *Hall*, Upper Helderberg Group, Clark Co., Ind	2
O. propinqua, *Hall*, Upper Helderberg Group, Columbus, Ohio	6
O. retrorsa, *Salter*, Hudson River Group, Cincinnati, Ohio	5
O. resupinata, *Martin*, Keokuk Group, Montgomery Co., Ind	4
O. sinuata, *Hall*, Hudson River Group, Madison, Ind	20
O. subquadrata, *Hall*, Hudson River Group, Madison, Ind.	21

	No. of Specimens.
O. testudinaria, Dalman, Hudson River Group, Madison, Ind . . .	32
O. tricenaria, Conrad, Hudson River Group, Madison, Ind	1
O. vanuxemi, Hall, Hamilton Group, Buffalo, N. Y	3
O. vanuxemi, Hall, Hamilton Group, Columbus, Ohio	5
Pentamerella papilionensis, Hall, U. Hel. Gr., Louisville, Ky. . . .	4
Pentamerus galeatus, Dalman, Niagara Group, Huntington, Ind . .	2
P. knappi, Hall, Niagara Group, Springfield, Ohio	1
P. knighti, Sowerby, see P. *laqueatus*, Conrad.	
P. laqueatus, Conrad, Niagara Group, Delphi, Ind	7
P. nysius, Hall, Niagara Group, Charlestown, Ind	7
P. nysius, Hall, Niagara Group, Huntington, Ind	4
P. oblongus, Sowerby, Niagara Group, Charlestown, Ind	15
P. ventricosus, Hall, Niagara Group, Madison, Ind	5
Productella dissimilis, Hall, Hamilton Group, Rockford, Iowa . . .	7
P. spinulicosta, Hall, Upper Helderberg Group, Charlestown, Ind .	90
P. subalata, Hall, Upper Helderberg Group, Falls of the Ohio. . .	7
Productus æquicostatus, Shumard, Coal Measures, Dubois Co, Ind . .	2
P. alpinus, Klein, Zeonhardi, St. Cassian.	24
P. biseriatus, Hall, Warsaw Group, Lanesville, Ind	2
P. cestriensis, Worthen, Kaskaskia Group, Leavenworth, Ind . . .	11
P. cestriensis, Worthen, Kaskaskia Group, Meade Co., Ky	12
P. cora var. mogoyoni, Marcou, Warsaw Group, Spergen Hill, Ind .	2
P. costatus, Hall, Coal Measures, Dubois Co., Ind	20
P. elegans, Worthen, Kaskaskia Group, Union Co., Ill	3
P. flemingi var. burlingtonensis, Hall, Burlington Group, Louisiana, Mo	2
P. keokuk, Hall, Keokuk Group, Putnam Co., Ind	2
P. longispinus, Sowerby, Coal Measures, Dubois and Posey Cos., Ind	37
P. longispinus, Sowerby, Coal Measures, Kansas City, Mo	2
P. magnus, M. & W., Keokuk Group, Jacksonville, Ind	2
P. magnus, M. & W., Keokuk Group, Crawfordsville, Ind	2
P. marginicinctus, Prout, St. Louis Group, Spergen Hill, Ind . . .	1
P. mesialis, Hall, Keokuk Group, Crawfordsville, Ind	2
P. nebraskensis, Owen, Permo-Carboniferous, Greenwood and Elk Cos., Kan	7
P. ovatus, Hall, St. Louis Group, Greencastle, Ind.	6
P. ovatus, Hall, St. Louis Group, Lanesville, Ind	22
P. parvus, M. & W., Kaskaskia Group, Meade Co., Ky	30
P. prattenanus, Norwood, Coal Measures, Kansas City, Mo.	2
P. punctatus, Martin, Coal Measures, Independence, Kan	2
P. punctatus, Martin, Keokuk Group, Crawfordsville, Ind.	5
P. semireticulatus, Martin, Permo-Carboniferous, Granada, Kan . .	3
P. semireticulatus, Martin, Keokuk Group, Jacksonville, Ind . . .	2

	No. of Specimens.
P. setigerus, *Hall*, Keokuk Group, Crawfordsville, Ind	6
P. tenuicostus, *Hall*, St. Louis Group, Greencastle, Ind	1
P. wortheni, *Hall*, Keokuk Group, Putnam Co., Ind	9
Retzia evax, *Hall*, Niagara Group, Waldron, Ind	544
R. mormoni, *Marcou*, Permo-Carboniferous, Fredonia, Kan	3
R. vera, *Hall*, St. Louis Group, Orange Co., Ind	4
R. vera, *Hall*, Kaskaskia Group, Wolf Creek, Ky	1
R. verneuiliana, *Hall*, Warsaw Group, Lanesville and Harristown, Ind.	100
Rhynchonella acinus, *Hall*, Niagara Group, Waldron, Ind	131
R. capax, *Conrad*, Hudson River Group, Madison, Ind	40
R. dentata, *Hall*, Hudson River Group, Madison, Ind	24
R. grosvenori, *Hall*, Warsaw, Group, Lanesville, Ind.	200
R. indianensis, *Hall*, Niagara Group, Waldron, Ind	300
R. macra, *Hall*, Warsaw Group, Lanesville, Ind	10
R. missouriensis, *Shumard*, Chemung Group, Cooper Co., Mo . . .	13
R. mutata, *Hall*, Warsaw Group, Lanesville, Ind	4
R. mutata, *Hall*, St. Louis Group, Alters, Ind	10
R. neglecta, *Hall*, Niagara Group, Waldron, Ind	304
R. ottumwa, *White*, St. Louis Group, Pella, Iowa	4
R. ricinula, *Hall*, Warsaw Group, Lanesville, Ind.	175
R. saffordi, *Hall*, Niagara Group, Perry Co., Tenn	4
R. stricklandi, *Sowerby*, Niagara Group, Waldron, Ind	23
R. subcuneata, *Hall*, Warsaw Group, Bloomington, Ind.	8
R. uta, *Marcou*, Kaskaskia Group, Orange Co., Ind	11
R. uta, *Marcou*, St. Louis Group, Orange Co., Ind	13
R. ventricosa, *Hall*, Hudson River Group, Madison, Ind	32
R. whitii, *Hall*, Niagara Group, Waldron, Ind	200
Rhynchotreta cuneata var. americana, *Hall*, Niagara Group, Waldron, Ind.	115
Schizocrania filosa, *Hall*, Hudson River Group, Madison, Ind . . .	6
Spirifera acuminata, *Conrad*, Upper Helderberg Group, Falls of the Ohio	8
S. acuminata, *Conrad*, Upper Helderberg Group, Columbus Ohio .	4
S. angusta, *Hall*, Upper Helderberg Group, Charlestown, Ind . . .	6
S. arctisegmenta, *Hall*, Upper Helderberg Group, Charlestown, Ind.,	4
S. atwaterana, *Owen*, Hamilton Group, Independence, Iowa	4
S. bimesialis, *Hall*, Hamilton Group, Independence, Iowa	2
S. biplicata, *Hall*, Knobstone Group, Morgan Co., Ind	5
S. camerata, *Morton*, Coal Measures, Kansas City, Mo	1
S. camerata, *Morton*, Coal Measures, Indiana	6
S. capax, *Hall*, Hamilton Group, Muscatine Co., Iowa	9
S. carteri, *Hall*, Knobstone Group, Clark and Washington Counties, Ind.	7

	No. of Specimens.
S. consobrina, *D'Orbigny*, Hamilton Group, Falls of the Ohio . . .	12
S. crispa, *Hall*, Niagara Group, Waldron, Ind	100
S. crispa var. simplex, *Hall*, Niagara Group, Waldron, Ind	30
S. cyrtiniformis, *Hall*, Chemung Group, Lime Creek, Iowa	1
S. disjuncta, *Sowerby*, Chemung Group, Chautauqua Lake, N. Y . .	2
S. disjuncta, *Sowerby*, Hamilton Group, Independence, Iowa . . .	1
S. divaricata, *Hall*, Upper Helderberg Group, Clark Co., Ind . . .	2
S. eudora, *Hall*, Niagara Group, Waldron, Ind	12
S. euruteines, *Owen*, Upper Helderberg Group, Charlestown, Ind .	23
S. forbesi, *N. & P.*, St. Louis Group, Gosport, Ind	1
S. granulifera, *Hall*, Hamilton Group, Oswego Lake, N. Y	2
S. gregaria, *Clapp*, Upper Helderberg Group, Falls of the Ohio . .	32
S. hungerfordi, *Hall*, Hamilton Group, Floyd Co., Iowa	13
S. hungerfordi, *Hall*, Hamilton Group, Cerro Gordo, Co., Iowa . .	7
S. increbescens, *Hall*, Kaskaskia Group, Meade Co., Ky	31
S. keokuk, *Hall*, Keokuk Group, Brown Co., Ind	1
S. keokuk, *Hall*, Warsaw Group, Ft. Dodge, Iowa	18
S. keokuk, *Hall*, Warsaw Group, Lanesville, Ind	31
S. keokuk var. shelbyensis, *Swallow*, St. Louis Group, Pella, Iowa . .	7
S. lævis, *Hall*, Portage Group, Ithica, N. Y	3
S. lævigata, *Swallow*, Keokuk Group, Rockhaven, Ky	4
S. lateralis, *Hall*, Warsaw Group, Lanesville, Ind	8
S. leidyi, *N. & P.*, Kaskaskia Group, Meade Co., Ky	45
S. leidyi, *N. & P.*, St. Louis Group, Orange Co., Ind	2
S. lineata, *Martin*, Coal Measures, Sullivan Co., Ind., and Belleville, Ill	5
S. logani, *Hall*, Keokuk Group, Crawfordsville, Ind	2
S. manni, *Hall*, Upper Helderberg Group, Clark Co., Ind	19
S. marionensis, *Shumard*, Kinderhook Group, Louisiana, Mo . . .	4
S. mesacostalis, *Hall*, Chemung Group, Ithica, N. Y	2
S. mortonana, *S. A. Miller*, Keokuk Group, Edwardsville, Ind. . .	15
S. mucronata, *Conrad*, Hamilton Group, Widder, Ont., Buffalo, N. Y., Clark Co., Ind	55
S. neglecta, *Hall*, Keokuk Group, Edwardsville, Ind	2
S. opima, *Hall*, Coal Measures, Dubois Co., Ind	3
S. orestes, *Hall*, Hamilton Group, Rockford, Iowa	12
S. oweni, *Hall*, Upper Helderberg Group, Charlestown, Ind . . .	21
S. parryana, *Hall*, Hamilton Group, Lime Creek, Iowa	2
S. plena, *Hall*, Keokuk Group, Gosport, Ind	1
S. pseudolineata, *Hall*, Keokuk Group, Edwardsville, Ind	15
S. radiata, *Sowerby*, Niagara Group, Waldron, Ind	20
S. raricosta, *Conrad*, Upper Helderberg Group, Falls of the Ohio .	3
S. rostellata, *Hall*, Keokuk Group, Alters, Ind	15

	No. of Specimens.
S. segmenta, Hall, Upper Helderberg Group, Charlestown, Ind . .	16
S. setigera, Hall, St. Louis Group, Wayport, Ind	8
S. spinosa, N. & P., St. Louis Group, French Lick, Ind	11
S. striatiformis, Meek, Keokuk Group, Edwardsville, Ind	8
S. striatiformis, Meek, Keokuk Group, Crawfordsville, Ind	1
S. subcuspidata, Hall, Keokuk Group, Crawfordsville, Ind	5
S. subæqualis, Hall, St. Louis Group, Rockhaven, Ky	5
S. suborbicularis, Hall, Keokuk Group, Rockhaven, Ky	7
S. texta, Hall, Knobstone Group, New Albany, Ind	4
S. tullia, Hall, Upper Helderberg Group, Falls of the Ohio . . .	6
S. tenuicostata, Hall, Warsaw Group, Orange Co., Ind.	4
S. tenuistriata, Hall, Keokuk Group, Edwardsville, Ind	10
S. varicosa, Hall, Upper Helderberg Group, Clark Co., Ind . . .	100
S. whitneyi, Hall, Hamilton Group, Cerro Gordo Co., Iowa . . .	6
Stenoschisma contractum, Hall, Chemung Group, Chautauqua, N. Y	1
S. contractum, Hall, Hamilton Group, New York	1
S. eximium, Hall, Chemung Group, New York	1
S. tethys, Billings, Upper Helderberg Group, Charlestown, Ind . .	147
Streptorhynchus crenistriatum, Phillips, Keokuk Group, Parke Co., Ind	1
S crenistriatum, Phillips, Keokuk Group, Edwardsville, Ind . . .	4
S. crenistriatum, Phillips, Warsaw Group, Lanesville, Ind.	5
S. filitextum, Hall, Hudson River Group, Frankfort, Ky	7
S. nutans, Meek, Hudson River Group, Madison, Ind	8
S. plano-convexum, Hall, Hudson River Group, Madison, Ind . . .	18
S. planumbonum, Hall, Hudson River Group, Richmond, Ind. . .	27
S. subplanum, Conrad, Niagara Group, Waldron, Ind	33
S. subtentum, Conrad, Hudson River Group, Madison, Ind	6
S. sulcatum, Verneuil, Hudson River Group, Hamilton, Ohio . . .	13
S. umbraculum, Von Buch, Knobstone Group, New Providence, Ind.	7
Strophodonta arcuata, Hall, Hamilton Group, Rockford, Iowa . . .	22
S. calvini, S. A. Miller, Hamilton Group, Rockford, Iowa	6
S. canace, Hall, Hamilton Group, Rockford, Iowa.	5
S. concava, Hall, Upper Helderberg Group, Charlestown, Ind . .	17
S. demissa, Conrad, Upper Helderberg Group, Charlestown, Ind .	14
S. demissa, Conrad, Hamilton Group, Independence, Iowa	23
S. hemispherica, Hall, Upper Helderberg Group, Charlestown, Ind.	8
S. inæquistriata, Conrad, Upper Helderberg Group, Columbus, Ohio,	3
S. semifasciata, Hall, Niagara Group, Waldron, Ind	8
S. striata, Hall, Niagara Group, Charlestown, Ind	1
Strophomena alternata, Conrad, Hudson River Group, Madison, Ind.	6
S. alternistriata, Hall, Hudson River Group, Madison, Ind	6
S. fracta, Meek, Hudson River Group, Madison, Ind.	12

	No. of Specimens.
S. nasuta, *Conrad*, Hudson River Group, Madison, Ind	13
S. rhomboidalis, *Wilckins*, Niagara Group, Hartsville, Ind., and Waldron, Ind	34
S. rhomboidalis, *Wilckins*, Niagara Group, Toledo, Ohio.	4
S. rhomboidalis, *Wilckins*, Upper Helderberg Group, Charlestown, Ind.	7
S. rhomboidalis, *Wilckins*, Keokuk Group, Jasper Co., Ind	6
S. tenuistriata, *Sowerby*, Hudson River Group, Richmond, Ind . .	30
Strophonella reversa, *Hall*, Hamilton Group, Floyd Co., Iowa . . .	1
Syntrielasma hemiplicata, *Hall*, Permo-Carboniferous, Eudora, Kan.,	5
Terebratula bovidens, *Morton*, Warsaw Group, Parke Co., Ind . . .	1
T. bovidens, *Morton*, Coal Measures, Kansas City, Mo	3
T. bovidens, *Morton*, Kaskaskia Group, Wolf Creek, Ky	2
T. formosa, *Hall*, Warsaw Group, Lanesville and Ellettsville, Ind.,	27
T. gregaria, Mesozoic, Germany	3
T. hastata, *Sowerby*, Warsaw Group, Lanesville and Harristown, Ind.	20
T. jucunda, *Hall*, Upper Helderberg Group, Falls of the Ohio . .	3
T. lincklœni, *Hall*, Upper Helderberg Group, Falls of the Ohio . .	4
T. lincklœni, *Hall*, Hamilton Group, Iowa City, Iowa	6
T. navicella, *Hall*, Hamilton Group, Rockford, Iowa.	5
T. suffeata, ——, Germany.	8
T. turgida, *Hall*, Warsaw Group, Lanesville and Bloomington, Ind.	263
T. turgida, *Hall*, St. Louis Group, Spergen Hill, Ind	13
Terebratula sp. Lias, Alps, Tyrol	15
Trematospira nobilis, *Hall*, Upper Helderberg Group, Charlestown, Ind.	1
Triplesia waldronensis, *M. & D.*, Niagara Group, Waldron, Ind . .	6
Tropidoleptus carinatus, *Conrad*, Upper Helderberg Group, Clark Co., Ind	27
T. carinatus, *Conrad*, Hamilton Group, New York	2
Whitfieldia maria, *Hall*, Niagara Group, Waldron, Ind.	29
Zygospira concentrica, *Ulrich*, Hudson River Group, Cincinnati, Ohio	4
Z. headi, *Billings*, Hudson River Group, Madison, Ind.	8
Z. modesta, *Say*, Hudson River Group, Madison, Ind	127
Z. modesta var. cincinnatiensis, *James*, Hudson River Group, Madison, Ind.	57

PTEROPODA.

	No. of Specimens.
Coleolus tenuicinctus, Hall, Upper Helderburg Group, Falls of the Ohio	1
C. tenuicinctus, Hall, Upper Helderberg Group, Charlestown, Ind .	5
Conularia crustula, White, Coal Measures, Kansas City, Mo	5
C. downii (?), Hudson River Group	1
C. micronema, Meek, Knobstone Group, Clark Co., Ind	30
C. missouriensis, Swallow, St. Louis Group, Rock Haven, Ky . . .	1
C. missouriensis, Swallow, Warsaw Group, Spergen Hill, Ind . . .	2
C. missouriensis, Swallow, Warsaw Group, Harristown, Ind	1
C. missouriensis, Swallow, St. Louis Group, Lanesville, Ind	3
C. newberryi, Winchell, Knobstone Group, New Albany, Ind . . .	1
C. niagarensis, Hall, Niagara Group, Grant Co., Ind	1
C. niagarensis, Hall, Niagara Group, Waldron, Ind	1
C. quadrisulcata (?), *Miller,* Niagara Group, Waldron, Ind. . . .	1
C. subcarbonaria, M. & W., Keokuk Group, Crawfordsville, Ind. .	13
Tentaculites fissurella, Hall, Marcellus Shale, New York	4
T. richmodensis, S. A. Miller, Hudson River Group, Richmond, Ind.	2
T. tenuistriatus, M. & W., Hudson River Group, Richmond, Ind .	21

GASTEROPODA.

Bellerophon bilobatus, Sowerby, Hudson River Group, Madison, Ind.	8
B. carbonarius, Cox, Coal Measures, Sullivan Co., Ind	12
B. carbonarius, Cox, Coal Measures, Kansas City, Mo	1
B. carbonarius, Cox, Permo-Carboniferous, Cedar Lake, Kan . . .	2
B. crenistria, Hall, Corniferous Group, Clark Co., Ind.	4
B. cyrtolites, Hall, Knobstone Group, Rockford, Ind.	7
B. gibsoni, White, St. Louis Group, Greencastle, Ind	16
B. gibsoni, White, St. Louis Group, Orange Co., Ind	2
B. montfortanus, N. & P., Coal Measures, Ohio	14
B. nodocarinatus, Hall, Coal Measures, Sullivan Co., Ind	1
B. patulus, Hall, Corniferous Group, Charlestown, Ind	2
B. pelops, Hall, Upper Helderberg Group, Charlestown, Ind . .	16
B. percarinatus, Upper Coal Measures (?), Sullivan Co., Ind . . .	5
B. sublævis, Hall, St. Louis Group, Ellettsville, Ind	17
B. sublævis, Hall, Warsaw Group, Spergen Hill, Ind	13
Bucania chicagoensis, McChesney, Niagara Group, Grant Co., Ind .	2
B. chicagoensis, McChesney, Niagara Group, Louisville, Ky	3
B. sp. inedt., St. Louis Group, Greencastle, Ind.	6
Cyclonema bilix, Conrad, Hudson River Group, Madison, Ind . . .	55
C. bilix, var. conicum, S. A. Miller, Hudson River Group, Madison Ind.	3

	No. of Specimens.
Cyclora minuta, Hall, Hudson River Group, Hamilton, Ohio . . .	Slab.
Crytolites ornatus, Conrad, Hudson River Group, Greene County, O	1
Euomphalus cyclostomus, Hall, Corniferous Group, Charlestown, Ind.	1
E. cyclostomus, Hall, Hamilton Group, Lime Creek, Iowa.	13
E. disjunctus, Hall, Niagara Group, Rensselaer, Ind	1
E. disjunctus, Hall, Niagara Group, Huntington, Ind	1
E. tioga, Hall, Corniferous Group, Charlestown, Ind	1
E. tioga, Hall, Upper Helderberg Group, Charlestown, Ind . . .	1
Isonema lichas, Hall, Upper Helderberg, Group, Charlestown, Ind.	2
Loxonema hydraulicum, H. & W., Hamilton Group, Charlestown, Ind.	3
L. hydraulicum, H. & W., Upper Helderberg Group, Clark Co., Ind.	18
L. teres, Hall, Corniferous Group, Charlestown, Ind.	13
L. teres, Hall, Corniferous Group, Falls of the Ohio.	8
Maclurea magna, LeSueur, Chazy Group, Basin Harbor, Vt. . . .	1
Macrochilina klipparti, Meek, Coal Measures, Dubois Co., Ind . . .	1
M. primigenia, Conrad, Coal Measures, Vigo Co., Ind	8
M. ponderosa, Swallow, Coal Measures, Sullivan Co., Ind	1
M. ventricosa, Hall, Coal Measures, Sullivan County, Ind.	2
M. ventricosa, Hall, Coal Measures, Vigo Co., Ind.	1
Murchisonia bellicincta, Hall, Hudson River Group, Madison, Ind .	1
M. gracilis, Hall, Hudson River Group, Madison, Ind	30
M. gracilis, Hall, Hudson River Group, Cincinnati, O	2
M. milleri, Hall, Hudson River Group, Cincinnati, O	4
M. milleri and M. gracilis, on a slab, Hudson River Group, Madison, Ind	
M. nebraskensis, Geinitz, Permo-Carboniferous, Pleasant Hill . . .	2
M. ventricosa, Hall, Hudson River Group, Madison, Ind	1
Naticopsis carleyana, Hall, Warsaw Group, Bloomington, Ind . . .	2
N. gigantea, Hall, Upper Helderberg Group, Falls of the Ohio . .	20
N. gigantea, Hall, Chemung Group, Cerro Gordo, Iowa	4
N. gigantea, Hall, Chemung Group, Rockford, Iowa.	9
N. gigantea, Hall, Hamilton Group, Floyd County, Ind	4
N. lævis, Meek, Corniferous Group, Charlestown, Ind	3
N. ventricosus, N. & P., Coal Measures, Kansas City, Mo.	1
Platyceras acutirostre, Hall, Warsaw Group, Lanesville, Ind. . . .	35
P. ammon, Hall, Upper Helderberg, Group, Charlestown, Ind . .	1
P. carinatum, Hall, Upper Helderberg Group, Falls of the Ohio .	4
P. carinatum, Hall, Upper Helderberg Group, Charlestown, Ind .	6
P. conicum, Hall, Upper Helderberg Group, Falls of the Ohio . .	2
P. cymbium, Hall, Upper Helderberg Group, Charlestown, Ind . .	11
P. cyrtolites, McChesney, Upper Coal Measures, New Harmony, Ind.	1

	No. of Specimens.
P. dumosum, Hall, Upper Helderberg Group, Charlestown, Ind.	14
P. dumosum, Hall, Upper Helderberg Group, Columbus, Ohio	4
P. dumosum, var. rarispinum, Hall, Upper Helderberg Group, Falls of the Ohio	2
P. echinatum, Hall, Upper Helderberg Group, Clark Co., Ind	1
P. equilaterale, Hall, Keokuk Group, Crawfordsville, Ind	14
P. erectum, Hall, Upper Helderberg Group, Charlestown, Ind	1
P. fissurellum, M. & W., Keokuk Group, Alters, Ind	2
P. haliotoides, M. & W., Knobstone Group, Rockford, Ind	1
P. multispinosum, Meek, Upper Helderberg Group, Falls of the Ohio	2
P. subundatum, Conrad, Upper Helderberg Group, Charlestown, Ind.	4
P. thetis, Hall, Upper Helderberg Group, Charlestown, Ind	1
P. ventricosum, Conrad, Upper Helderberg Group, Charlestown, Ind	1
Platystoma hemisphericum, Hall, Niagara Group, Delphi, Ind	1
P. niagarense, Hall, Niagara Group, Delphi, Ind	1
P. niagarense, Hall, Niagara Group, Waldron, Ind	38
Pleuronotus, decewi, Billings, Upper Helderberg Group, Falls of the Ohio	10
P. decewi, Billings, Corniferous Group, Columbus, Ohio	3
Pleurotomaria carbonaria, N. & P., Coal Measures, Dubois Co., Ind	1
P. ella, Hall, Niagara Group, Delphi, Ind	1
P. grayvillensis, N. & P., Coal Measures, Vigo Co., Ind	4
P. hoyi, Hall, Niagara Group, Huntington, Ind	1
P. idia, Hall, Niagara Group, Huntington, Ind	1
P. imitator, Hall, Corniferous Group, Charlestown, Ind	5
P. lucina, Hall, Corniferous Group, Bartholomew Co., Ind.	1
P. lucina, Hall, Corniferous Group, Charlestown, Ind	2
P. lucina, var. perfasciata, Hall, Upper Helderberg Group, Clark Co., Ind	1
P. meekana, Hall, Warsaw Group, Bloomington, Ind	—
P. nodulostriata, Hall, Warsaw Group, Spergen Hill, Ind	1
P. nodulostriata, Hall, Warsaw Group, Ellettsville, Ind	1
P. occidens, Hall, Niagara Group, Delphi, Ind	1
P. occidens, Hall, Niagara Group, Randolph Co., Ind	6
P. shumardi, M. & W., Keokuk Group, Crawfordsville, Ind	3
P. sphærulata, Conrad, Coal Measures, Vigo Co., Ind	32
P. sulcomarginata, Conrad, Corniferous Group, Watson's Station, Ind.	36
P. sulcomarginata, Conrad, Hamilton Group, Clark Co., Ind	5
P. tabulata, Conrad, Coal Measures, Vigo Co., Ind	28
P. wortheni, Hall, Warsaw Group, Spergen Hill, Ind	3
P. sp., Knobstone Group, Clark Co., Ind	11

	No. of Specimens.
P. sp., Upper Helderberg Group, Charlestown, Ind	1
P. sp., Niagara Group, Delphi Ind	1
Straparollus lens, Hall, Knobstone Group, Rockford, Ind	7
S. planidorsalis, M. & W., Chester Group, Orange Co., Ind	4
S. spergenensis, Hall, Warsaw Group, Spergen Hill, Ind	18
S. spergenensis, Hall, Warsaw Group, Bloomington, Ind	13

CEPHALOPODA.

Ammonites armatus, Cretaceous-Mesozoic, England	1
A. bisulcatus, Brug, Lower Lias, Rautenberg, Brunswick	2
A. cordatus, Sow, Middle Oölite, Calvados, France	1
A. crassus, Phillips, Upper Lias, Whitby, England	1
A. fimbriatus, Sow, Middle Lias, Charmouth, England	1
A. henleyi, Sow, Lias, Charmouth, England	1
A. mantelli, Sow, Cretaceous, St. Florentine, France	1
A. marlini, D' Orbigny, Lower Greensand, England	1
A. modiolaris, Luid, Middle Oölite, Wiltshire, England	1
A. obtusus, Sow, Lower Lias, Charmouth, England	1
A. serpentinus, Schloth, Lias Boll, Wirtemberg	1
A. coronatus, Brug, Middle Oölite, Villere, France	1
Arcestes monticola, Schlothein, Europe	1
A. oligofarcus, Mojs, Europe	1
Conularia subcarbonaria, M. & W., Keokuk Group, Crawfordsville, Ind	2
Cyrtoceras ohioense, Meek, Corniferous Group, Columbus, Ohio	1
C. ohioense, Meek, Corniferous Group, Charlestown, Ind	1
Discites disciformis, M. & W., Keokuk Group, Brown Co., Ind	
Discososus conoideus, Hall, Niagara Group, Wilmington, Ohio	1
Endoceras magniventrum, Hall, Hudson River Group, Madison, Ind	1
E. proteiforme, Hall, Hudson River Group, Franklin Co., Ind	1
Gomphoceras oviforme, Hall, Upper Helderberg Group, Charlestown, Ind	7
G. raphanus, Hall, Upper Helderberg Group, Charlestown, Ind	6
G. septore, Hall, Niagara Group, Delaware Co., Ind	1
G. septore, Hall, Niagara Group, Delphi, Ind	2
G. septore, Hall, Niagara Group, Wabash, Ind	2
G. subgracile, Hall, Niagara Group, Delphi, Ind	1
G. subgracile, Billings, Niagara Group, Wabash, Ind	1
G. subgracile, Billings, Niagara Group, Charlestown, Ind	1
G. turbiniforme, M. & W., Corniferous Group, Charlestown, Ind	5
Goniatites ixion, Hall, Knobstone Group, Rockford, Ind	3
G. ixion, Hall, Knobstone Group, Rockford, Ind	5

	No. of Specimens.
G. lyoni, M. & W., Knobstone Group, Rockford, Ind	4
G. oweni, Hall, Knobstone Group, Rockford, Ind	5
Goniatites oweni, Hall, Knobstone Group, Rockford, Ind	13
G. oweni, var. parallelus, Hall, Knobstone Group, Rockford, Ind	15
G. oweni, var. parallelus, Hall, Knobstone Group, Rockford, Ind	5
Gyroceras cyclops, Hall, Upper Helderberg Group, Marion, Ohio	1
Gyroceras elrodi, White, Niagara Group, Hartsville, Ind	6
G. elrodi, White, Niagara Group, Delaware Co., Ind.	3
G. elrodi, White, Niagara Group, St. Paul, Ind.	2
G. elrodi, White, Niagara Group, Waldron, Ind.	1
G. spinosum, Conrad, Corniferous Group, Logansport, Ind	1
Gyroceras inelegans, Meek, Middle Devonian, Falls of the Ohio	1
Helioceras rotundum, Sow, Gault, Folkestone, Eng.	1
Lituites marshi, Hall, Niagara Group, Wabash, Ind	9
L. marshi, Hall, Niagara Group, Eaton, Ind	1
L. marshi, Hall, Marion, Ind.	2
L. species, Niagara Group, Upper Silurian, Delphi, Ind	1
Nautilus clarkanus, Hall, St. Louis Group, Tippecanoe Co., Ind	1
N. coxanus, Meek & W., Warsaw Group, Lanesville, Ind	4
Nautilus decoratus, Cox, Coal Measures, Vigo County, Ind	2
N. elegans, Sow, Cretaceous-Mesazoic, England	1
N. kentuckiensis, Yandell, Keokuk Group, Bullitt Co., Ky	1
N. occidentalis, Swallow, Coal Measures, Dubois County, Ind	2
N. planorbiformis, M. & W., Coal Measures, Dubois County, Ind	1
N. rockfordensis, M. & W., Knobstone Group, Jackson Co., Ind.	1
N. species, St. Louis Group, Ellettsville, Monroe Co., Ind	1
N. species	1
Ormoceras species	1
O. vertebratum, Hall, Niagara Group, North Vernon, Ind.	2
Orthoceras abnorme, Hall, Niagara Group, North Vernon, Ind,	5
O. amycus, Hall, Niagara Group, St. Paul, Ind.	1
O. annulatum, Sowerby, Niagara Group, St. Paul, Ind	7
O. annulatum, Sowerby, Niagara Group, Hartsville, Ind	1
O. annulatum, Sowerby, Niagara Group, Grant Co., Ind	1
O. annulatum, Sowerby, Niagara Group, Waldron, Ind.	3
O. bebryx, Hall, Chemung Group, Ithaca, N. Y.	1
O. clavatum, Hall, Niagara Group, Upper Silurian, North Vernon, Ind.	1
Orthoceras columnare, Hall, Niagara Group, Wabash, Ind	1
O. crebristriatum, Niagara Group, Waldron, Ind	2
O. crebescens, Hall, Niagara Group, Grant Co., Ind	1
O. crebescens, Hall, Niagara Group, Grant Co., Ind	3
O. crebescens, Hall, Niagara Group, Miami Co., Ind	1

	No. of Specimens.
O. crebescens, *Hall*, Niagara Group, Wabash, Ind	2
O. crebescens, *Hall*, Niagara Group, Delaware Co., Ind	1
O. crebescens, *Hall*, Niagara Group, North Vernon, Ind	1
O. duseri, *H. & W.*, Hudson River Group, Hamilton, O	2
O. heterocinctum, *Winchell*, Knobstone Group, Rockford, Ind . . .	9
O. imbricatum, *Sowerby*, Niagara Group, St. Paul	5
O. longicameratum, *Hall*, Niagara Group, Waldron, Ind	1
O. rushense, *McChesney*, Coal Measures, Vigo Co., Ind.	12
O. simulator, *Hall*, Niagara Group, Wabash, Ind	1
O. sociale, *Hall*, Hudson River Group, Latnerville, Dubuque Co., Iowa	3
O. unidentified species, Niagara Group, Delaware Co., Ind . . .	1
O. unidentified species, Niagara Group, St. Paul, Ind	3
O. unidentified species, Niagara Group, Kentland, Ind	2
O. subcancellatum, *Hall*, Niagara Group, St. Paul, Ind	5
O. subcancellatum, *Hall*, Niagara Group, Waldron, Ind	1
O. subulatum, *Hall*, Niagara Group, Waldron, Ind	1
O. subulatum, *Hall*, Marcellus Shale, East Winfield, N. Y	1
Orthoceras subulatum, *Hall*, Marcellus Group, Union Springs, N. Y.	1
O. strix, *Hall & W.*, Niagara Group, Delphi, Ind	7
O. strix, *H. & W.*, Niagara Group, Grant Co., Ind	1
O. whitii, *Winchell*, Knobstone Group, Rockford, Ind	13
Phragmoceras ellipticum, *H. & W.*, Niagara Group, Utica, Clark Co., Ind.	1
P. ellipticum, Niagara Group, Grant Co., Ind	1
P. ellipticum, *H. & W.*, Wabash, Ind	1
P. nestor, *Hall*, Niagara Group, Grant Co., Ind	1
P. nestor, *Hall*, Niagara Group, Marion, Ind	1
P. nestor, *Hall*, Niagara Group, Monon, Ind	2
P. parvum, *Hall & W.*, Niagara Group, Grant Co., Ind	1
P. unidentified species, Corniferous Group, Charlestown, Ind . .	1
P. unidentified species, Niagara Group, Huntington, Ind	1
P. walshi (?), *M. & W.*, Corniferous Group, Jeffersonville, Ind. .	1
Regoceras subangulare, Lower Lias, Neumarye	1
Scaphites æqualis, *Sowerby*, Cretaceous, Rouen, France	1
S. æqualis, *Sowerby*, Chalk, Rouen, France	1
S. iyaii, *Puzos*, Lower Greenland, Barreme, France	1
Siphuncle ormoceras, Niagara Group, St. Paul Station, Ind	1
Streptorhynchus umbraculum, *Von Buch*, Knobstone Group, New Providence, Ind	6
Temnochilus coxanum, *M. & W.*, St. Louis Group, Greencastle, Ind.	6
T. coxanum, *M. & W.*, St. Louis Group, Orange Co., Ind	1
T. winslowi, *M. & W.*, Coal Measures, Dubois Co., Ind.	1

	No. of Specimens.
Trochoceras baeri, M. & W., Hudson River Group, Richmond, Ind .	1
T. richmondensis, Hudson River Group.	1
T. unidentified species, Niagara Group, Charlestown, Ind	1
T. waldronense, *Hall*, Niagara Group, Waldron, Ind	3

LAMELLIBRANCHIATA.

Allorisma cuneatum, *Swallow*, Coal Measures, Warren Co., Ind. . .	1
A. granosum, *Shumard*, Permo-Carboniferous, Greenwood Co., Kan.	1
A. sinuatum, *McChesney*	22
A. subcuneatum, *M. & H.*, Coal Measures, Dubois Co., Ind	7
Ambonychia acutirostra, *Hall*, Niagara Group, Waldron, Ind . . .	3
A. bellistriata, *Hall*, Hudson River Group, Franklin Co., Ind . . .	1
A. carinata, *Goldfuss*, Hudson River Group, Madison, Ind	9
A. costata, *Meek*, Hudson River Group, Madison, Ind	4
A. radiata, *Hall*, Hudson River Group, Richmond, Ind	8
Arca acuminata, Vicksburg Group, Mississippi.	2
Astarte perplana	2
Astartella concentrica, *McChesney*, Coal Measures, Sullivan Co., Ind .	1
Aviculopecten amplus, *M. & W.*, Keokuk Group, Edwardsville, Ind.	1
A. aviculatus, *Swallow*, Coal Measures, Dubois Co., Ind.	1
A. carboniferous, *Stevens*, Coal Measures, Dubois Co., Ind	1
A. crassicostatus, *Hall*, Upper Helderberg Group, Charlestown, Ind.	11
A. fragilis, *Hall*, Marcellus Shale, Erie Co., N. Y	2
A. indianensis, *M. & W.*, Keokuk Group, Crawfordsville and Edwardsville, Ind.	3
A. intercostalis, *Winchell*, Upper Helderberg Group, Charlestown, Ind.	1
A. oblongus, *M. & W.*, Keokuk Group, Edwardsville, Ind	1
A. occidentalis, *Shumard*, Permo-Carboniferous, Elk Co., Kan . . .	2
A. pecteniformis, *Conrad*, Upper Helderberg Group, Charlestown, Ind.	4
A. providencensis, *Cox*, Coal Measures, Dubois Co., Ind.	4
Cardita granulata	2
Cardium laqueatum, *Conrad*, Miocene, James River, Vir (?)	3
Conocardium attenuatum, *Conrad*, Niagara Group, Waldron, Ind . .	3
C. cuneatum, *Hall*, Warsaw Group, 3 Spergen Hill, Ind	7
C. trigonale, *Hall*, Upper Helderberg Group, Charlestown, Ind . .	27
Corbula graysonensis, *Cretaceous*, Sherman, Tex	1
C. ideona	2
Crassatella undulata	2
Cypricardites hindi, *Billings*, Hudson River Group, Green Co., Ohio	1

	No. of Specimens.
C. sterlingensis, M. & W., Hudson River Group, Richmond and Madison, Ind	4
Exogyra arietina, Roemer, Cretaceous, Dennison, Texas	3
E. forniculata, White, Cretaceous, Dennison, Texas	1
E. matheroniana, D'Orbigny, Cretaceous, Ft. Worth, Texas	2
Gryphea pitcheri, Morton, Cretaceous, Dennison Texas	10
G. wacoensis, Roemer, Cretaceous, Ft. Worth, Texas	1
Lithophaga lingualis, Phillips, Keokuk Group, Crawfordsville, Ind.	1
L. pertenuis, M. & W., Warsaw Group, Lanesville, Ind	4
Lunulicardium fragilis, Hall, Chemung Group, Ithica, N. Y.	1
Lima wacoensis, Roemer, Cretaceous, Ft. Worth, Texas	1
Modiolopsis cincinnatiensis, H. & W., Hudson River Group, Richmond, Ind.	3
M. dubia, Hall, Niagara, Group, St. George Island, Lake Erie	4
M. modiolaris, Conrad, Hudson River, Group, Richmond, Ind	3
M. modiolaris, Conrad, Hudson River Group, Hamilton, Ohio	4
M. perlata, Hall, Niagara Group, Waldron, Ind.	1
M. pholadiformis, Hall, Hudson River Group, Hamilton, Ohio.	2
M. subalata, Hall, Niagara Group, Waldron, Ind.	7
M. terminalis, Hall, Hudson River Group, Oxford, Ohio	3
M. truncata, Hall, Hudson River Group, Hamilton, Ohio	3
M. ——, Corniferous Group, Charlestown, Ind	4
Monopteria longispina, Cox, Coal Measures, Dubois Co., Ind	2
Myalina keokuk, Worthen, Keokuk Group, Edwardsville, Ind.	1
M. perattenuata, Meek & Hayden, Permian, Butler Co., Kan.	1
M. swallovi, McCoy, Coal Measures, Dubois Co., Ind	1
Myochoneha incurva	——
Mytilarca sigilla, Hall, Niagara Group, Waldron, Ind.	2
Neitha texana, Cretaceous, Dennison, Texas	4
Nucleospira barrisi, White, Knobstone Group, Rockford, Ind.	3
Nucula bellistriata, Conrad, Upper Coal Measures, Fayette Co., Ill	2
N. lineata, Goldfuss, St. Cassian	12
N. lirata, Conrad, Hamilton Group, Buffalo, N. Y.	2
N. niotica, Hall, Upper Helderberg Group, Charlestown, Ind	8
N. parva, McChesney, Upper Coal Measures, Fayette Co., Ill.	1
N. ventricosa, Hall, Coal Measures, Belleville, Ill.	5
Orthodesma parallelum, Hall, Hudson River Group, Madison, Ind., Cincinnati, Ohio	5
O. rectum, H. & W., Hudson River Group, Madison, Ind	1
Ostrea belliplicata, Shumard, Cretaceous, Sherman, Texas	6
O. blackii, White, Cretaceous, Sherman, Texas	1
O. carinata, Lamrck, Cretaceous, Ft. Worth, Texas	3
O. congesta, Conrad, Cretaceous, Ellis Co., Kan	——

	No. of Specimens.
O. crenulimargo, *Roemer*, Cretaceous, Dennison and Ft. Worth, Tex.	3
Paracyclas elliptica, *Hall*, Upper Helderberg Group, Falls of the Ohio	9
P. elliptica, *var. occidentalis*, *Hall*, Upper Helderberg Group, Charlestown, Ind	19
P. lirata, *Conrad*, Upper Helderberg Group, Columbus, Ohio	67
P. sabini, *White*, Hamilton Group, Rockford, Iowa	5
Pectunculus ovatus, Miocene, James River, Vir	2
P. tumuli	2
Pinna peracuta, *Shumard*, Kaskaskia Group, Orange Co., Ind.	2
P. subspatulata, *Worthen*, Keokuk Group, Crawfordsville, Ind	2
Pseudomonotis hawni, *M. & H.*, Permo-Carboniferous, Greenwood Co., Kan	2
Pterinea brisa, *Hall*, Niagara Group, Waldron, Ind	2
P. concentrica, *Conrad*, Upper Helderberg Group, Charlestown, Ind	1
P. demissa, *Conrad*, Hudson River Group, Madison, Ind	4
P. flabellum, *Conrad*, Hamilton Group, Cayuga Lake, N. Y.	2
P. flabellum, *Conrad*, Upper Helderberg Group, Falls of the Ohio, Ind	5
Sanguinolites sanduskyensis, *Meek*, Upper Helderberg Group, Columbus, Ohio	4
Schizodus wheeleri, *Swallow*, Permo-Carboniferous, Elk Co., Kan	1
Solen scalpriformis, *Winchell*, Stony Point, Mich	1
Solenomya anodontoides, *Meek*, Coal Measures, Dubois Co., Ind	1
Tellinomya levata, *Hall*, Hudson River Group, Dubuque, Iowa.	29
Trigonia emargi, Cretaceous, Dennison, Texas.	1

ANNELIDA.

Cornulites proprius, *Hall*, Niagara Group, Waldron, Ind	18
Spirorbis carbonarius, *Dawson*, Coal Measures, Newburg, Ind	2

CRUSTACEA.

Calymene blumenbachi, *Brongniart*, Niagara Group, Madison, Ind	16
C. callicephala, *Green*, Hudson River Group, Cincinnati, Ohio	4
C. callicephala, *Green*, Hudson River Group, Madison, Ind	15
C. niagarensis, *Hall*, Niagara Group, Grafton, Ill	3
C. niagarensis, *Hall*, Niagara Group, Fayette Co., Ind	4
C. niagarensis, *Hall*, Niagara Group, Waldron, Ind	66
Ceraurus niagarensis, *Hall*, Niagara Group, Marion, Ind	1
C. niagarensis, *Hall*, Niagara Group, Waldron, Ind	4
C. pleurexanthemus, *Green*, Hudson River Group, Cincinnati, Ohio	1

	No. of Specimens.
Cyphaspis christyi, Hall, Niagara Group, Waldron, Ind	11
Dalmanites limulurus, Green, Niagara Group, Louisville, Ky	2
D. limulurus, Green, Niagara Group (plaster cast)	——
D. limulurus, Green, Niagara Group, Madison, Ind	1
D. limulurus, Green, Niagara Group, Jefferson Co., Ind	5
D. micrurus, Green, Niagara Group, Louisville, Ky	1
D. ohioensis, Meek, Upper Helderberg Group, Falls of the Ohio	1
D. ohioensis, Meek, Upper Helderberg Group, Charlestown, Ind	1
D. pleuropteryx, Green, Niagara Group, Louisville, Ky	5
D. verrucosus, Hall, Niagara Group, Waldron, Ind	56
D. vigilans, Hall, Niagara Group, Waldron, Ind	4
Dicellocephalus minnesotensis (?), Owen, Potsdam Group (plaster cast)	——
Eurypterus remipes, De Kay, Corniferous Group, Put-in-Bay Island, Ohio	3
Homalonotus delphinocephalus, Green, Niagara Group, Waldron, Ind	1
H. delphinocephalus, Green, Waldron, Ind	2
H. vanuxemi, Hall, Niagara Group, Louisville, Ky.	2
Illaenus armatus, Hall, Niagara Group, Waldron, Ind	6
I. armatus, Hall, Niagara Group, Charlestown, Ind	1
I. ioxus, Hall, Niagara Group, Renssalear, Ind	1
Isotelus gigas, De Kay, Hudson River Group, Greene Co., Ohio	1
I. gigas, De Kay, Hudson River Group, Cincinnati, Ohio	1
I. gigas, De Kay, Labrum or Epistoma, Hudson River Group, Richmond, Ind.	4
I. gigas De Kay, Labrum, Hudson River Group, Blanchester, Ohio.	1
I. gigas, De Kay, Hudson River Group (plaster casts)	4
I. megistus, Locke, Hudson River Group (plaster cast)	1
I. megistus, Locke, Hudson River Group, Cincinnati, Ohio.	2
Lichas boltoni, Bigsby, Niagara Group, Lockport, N. Y. (plaster cast)	——
L. boltoni, var. occidentalis, Hall, Niagara Group, Waldron, Ind	——
L. breviceps, Hall, Niagara Group, Jefferson Co., Ind	2
L. breviceps, Hall, Niagara Group, Waldron, Ind	1
Pygidium of Lichas, Devonian, Germany	1
Phacops bufo, Green, Upper Helderberg Group, Charlestown, Ind.	5
P. bufo, Green, Upper Helderberg Group, North Vernon, Ind	3
P. bufo, Green, Upper Helderberg Group, Charlestown, Ind	15
P. bufo Green, Upper Helderberg Group, Falls of the Ohio	1
P. bufo Green, Hamilton Group, Buffalo, N. Y	10
P. bufo, Green, Upper Helderberg Group, Jefferson Co., Ind	1
P. bufo, Green, Upper Helderberg Group, Charlestown, Ind.	26
P. bufo (?), Schoharie Grit, Pendleton, Ind	——
Phillipsia bufo, M. & W., Keokuk Group, Crawfordsville, Ind	6

	No. of Specimens
P. bufo, M. & W., Keokuk Group, Jacksonville, Ind.	1
P. major, Shumard, Coal Measures, Kansas City, Mo.	2
P. meramecensis, Shumard, Warsaw Group, Bloomington, Ind. . . .	1
P. meramecensis, Shumard, Warsaw Group, Lanesville, Ind	11
P. portlocki, M. & W., Keokuk Group, Crawfordsville, Ind. . . .	1
P. sangamonensis, M. & W., Coal Measures, Dubois Co., Ind. . . .	2
P. sangamonensis, M. & W., Coal Measures, Fayette Co., Ill. . . .	1
P. stevensoni, Meek, Chester Group, Orange Co., Ind	2
Proetus crassimarginatus, Hall, Upper Helderberg Group, Falls of the Ohio, Indiana side.	1
P. longicaudus, Hall, Upper Helderberg Group, Falls of the Ohio .	1
P. planimarginatus, Meek, Upper Helderberg Group, Falls of the Ohio	1
Sphærexochus mirus, Niagara Group, Europe (plaster cast)	1
S. romingeri, Hall, Niagara Group, Waldron, Ind	5
Trirathrus becki, Green, Utica slate, Holland Patent, N. Y.	2
Trinucleus concentricus, Eaton, Utica slate, Cincinnati, Ohio	1

LIST OF DUPLICATE FOSSILS.

Acervularia davidsoni	16
Actinocrinus lowii, Hall	3
Ambonychia radiata, Hall	9
Anostrophia verneuili, Hall	339
Athyris hirsuta, Hall	343
A. sublamellosa, Hall	120
A. subquadrata, Hall	441
A. trinuclea, Hall	1920
A. vittata, Hall	39
Atrypa riticularis, Linne	1650
Batocrinus biturbinatus, Hall	5
B. rotundus, O. & S	21
Blothrophyllum decorticatum, Billings	54
B. promissum, Hall	22
Buthotrephis gracilis, Hall	1
Calymane blumenbachi, Brongniart	93
C. callicephala, Green	4
Chonetes yandellanus, Hall	79
Clisiophyllum oneidiense, Billings	2
Cyathophyllum corniculum	51
C. radicula, Rominger	480
C. rugosum, Hall	36
C. validum, Hall	42

	No. of Specimens.
Cyclonema bilix, Conrad	16
Cystiphyllum americanum, E. & H	35
C. ohiœnse, Nicholson	32
C. sulcatum, Billings	8
C. vesiculosum, Goldfuss	52
Diphyphyllum archiaci, Billings	21
D. cæspitosum, Hall	2
D. colligatum	3
D. simcœnse, Billings	1
Eridophyllum rugosum, E. & H	25
Eucalyptocrinus, cœlatus, Hall	15
E. crassus, Hall	160
E. ornatus (?), Hall	37
Favistella stellata, Hall	80
Favosites canadensis, Billings	1
F. emmonsi, Rominger	82
F. epidermatus, Rominger	32
F. favosus, Goldfuss	45
F. forbesi var. occidentalis, Hall	666
F. hemisphericus, Troost	224
F. limitaris, Rominger	227
F. niagarensis, Hall	31
F. pirum, Davis	54
F. tuberosus, Rominger	44
Goniasteroidocrinus tuberosus, L. & C	10
Goniatites ixion, Hall	10
G. oweni, Hall	60
G. oweni var. parallelus, Hall	90
Halysites catenulatus, Linne.	116
Heliolites interstinctus, Linne	35
H. megastoma, McCoy	65
Heliophylum gemmatum, Hall	7
Leptœna sericea, Sowerby	58
Lichenalia concentrica, Hall.	236
Lithostrotion proliferum, Hall	48
Lunulicardium sp. (?)	1
Lyriocrinus melissa, Hall	44
Meristina nitida, Hall	2908
Michelina cylindrica	1
Monticulipora cincinnatiensis, James	1
M. dalii, E. & H	314
M. discoidea, Nicholson	16
M. frondosa, D'Orbigny	7

	No. of Specimens.
M. gracilis, Hall	20
Onychocrinus exculptus, L. & C	6
Orthis biforata, Schlotheim	478
O. dentata, Pander	162
O. impressa, Hall	20
O. laticosta, Meek	784
O. lynx, Eichwald	821
Orthis occidentalis, Hall	106
O. sinuata, Hall	351
O. subquadrata, Hall	68
Orthoceras whitii, Winchell	23
Paracyclas elliptica, Hall	40
P. lirata, Conrad	39
Pentamerus knighti, Sowerby	36
P. oblongus, Sowerby	8
Pentremites connoideus, Hall	1887
Phacops bufo, Green	83
Plasmopora follis, E. & H	61
Platyceras equilaterale, Hall	27
Platycrinus hemisphericus, M. & W	102
Platystoma niagarense, Hall	258
P. shumardi, Verneuil	21
Pleuronotus decewi, Hall	3
Pleurotomaria occidens, Hall	3
P. subconica, Hall	40
P. sulcomarginata, Conrad	168
Poteriocrinus coreyi, Worthen	13
Productella spinulicostata, Hall	153
Raphistoma lenticulare, Emmons	33
Retzia evax, Hall	4762
R. verneuiliana, Hall, Eumetria verneuiliana	47
Rhynchonella capax, Conrad	579
R. indianensis, Hall	4488
R. stricklandi, Sowerby	105
R. ventricosa, Hall	7
R. whitii, Hall	870
Rhynchotreta cuneata var. americana, Hall	681
Scaphiocrinus æqualis, Hall	8
S. decadactylus, Worthen	4
Stenoschisma tethys, Billings	192
Streptelasma corniculum, Hall	772
Streptorhynchus planumbonum, Hall	52
S. planoconvexum, Hall	37

	No. of Specimens.
S. umbraculum, Von Buch	39
Stromatopora mamillata, Nicholson	1
Strombodes pentagonus, Goldfuss	4
Strophodonta demissa, Conrad	10
S. hemispherica, Hall	12
Strophomena alternata, Conrad	219
S. alternistriata, Hall	17
S. fracta, Meek	17
S. nasuta, Conrad	29
S. rhomboidalis, Wilckins	101
Spirifera acuminata, Conrad	47
S. fornacula, Hall	42
S. keokuk, Hall	77
Spirifera oweni, Hall	510
S. pennata, Atwater	15
S. radiata, Sowerby	125
S. varicosa, Hall	340
Spirifera sp. (?)	30
Thecia major, Rominger	51
T. minor, Rominger	11
Whitfieldia maria, Hall	692
Zaphrentis dalei, E. & H	177
Z. elegans, Hall	13
Z. gigantea, Leseuer	21
Z. prolifica, Billings	14
Z. rafinesquii, E. & H	4
Z. spinulifera, Hall	141
Z. spinulosa, E. & H	29
Z. yandelli	28
Zggospira modesta, Say (Slabs.)	9

BUILDING AND OTHER STONES.

The following is a list of the building and other stones contained in the State collection. The specimens were obtained mainly from the State House Commissioners, and consist of the samples submitted for their inspection with the view of securing the adoption of the various grades for use in construction of the Capitol. It is the design of the State Geologist to procure from all the quarries of the State suitable samples of the stone they furnish, and put them on permanent exhibition, in suitable cases, where they may be examined at any time by architects and others who contemplate using such material in buildings or structures of any kind:

LARGE BUILDING STONE.

1. Oolitic Limestone, Vorhees & Norton.
2. Sub-Carboniferous Sandstone, Grafton, Ohio.
3. Red Granite, Jonesboro, Maine.
4. Red Granite, Clayton, N. Y.
5. Gray Granite, Derby, Vt.
6. Niagara Limestone, Greensburg, Ind.
7. Niagara Limestone, Greensburg, Ind.
8. Niagara Limestone, St. Paul, Ind.
9. American Red Granite, Maine.
10. Lithographic Limestone, Corydon, Ind.
11. Oolitic Limestone, Stinesville, Ind.
12. Devonian Limestone, North Vernon, Ind.
13. Sub-Carboniferous Sandstone, Grafton, Ohio.
14. Oolitic Limestone, Ellettsville, Ind.
15. American Granite, Richmond, Va.
16. Niagara Limestone, St. Paul, Ind.
17. Oolitic Limestone, Bedford, Ind.
18. Oolitic Limestone, Baalbec Quarry, Bedford, Ind.
19. Oolitic Limestone, Ellettsville, Ind.
20. American Granite, Maine.

SPECIMENS OF BUILDING AND OTHER STONES.

MARBLE AND BUILDING STONE.

		No. of Specimens.
1.	American White Marble, Swanton, Vt	1
2.	American White Marble, slightly clouded, Swanton, Vt	1
3.	American White Marble, clouded, Swanton, Vt.	1
4.	Dark Blue Vermont Marble, Swanton, Vt	1
5.	Swanton Dove Marble, Swanton, Vt	1
6.	Dark Gray Marble, Isle La Molle, Swanton, Vt	1
7.	Dark Chocolate, Mottled Marble, Swanton, Vt.	1
8.	Red Vitulano Marble, Beneventano, Italy	1
9.	Dark Mariah Marble, Vermont	1
10.	Shell Marble, Tennessee	1
11.	Italian Marble, Italy	1
12.	Red Champlain Marble, Poultney State Works, N. Y. City	1
13.	Florentine Marble, Burlington Manufacturing Co	1
14.	Red Vitulano Marble, Beneventano, Italy	1
15.	Dark Red Tennessee Marble.	1
16.	Italian Marble, Italy	1

		No. of Specimens
17.	Mottled Tennessee Marble	1
18.	Italian Marble, Florence, Italy	1
19.	Tennessee Marble, Knoxville, Tenn	1
20.	Red Tennessee Marble, Holston River, Tenn	1
21.	Italian Marble, Florence, Italy	1
22.	Italian Marble, Italy	1
23.	Red Tennessee Marble, Tenn	1
24.	Dark Blue Marble, Vermont	1
25.	Verde Antique Marble	1
26.	Olive Variegated Marble, McMinn Co., Tenn	1
27.	Black Marble, Glens Falls, N. Y.	1
28.	Red Lake Champlain Marble, New York	1
29.	White Marble, Vermont	1
30.	Dark Mariah Marble, Burlington Manufacturing Co.	1
31.	Dove Marble, Sutherland Falls, Vt.	1
32.	Black Marble, Glens Falls, N. Y.	1
33.	Italian Marble, Italy	1
34.	Governeur Marble, Southerland Falls, Vt	1
35.	Egyptian Marble	1
36.	Winooski Marble	1
37.	Dark Brocatello Marble, Vermont	1
38.	Lyonaise Marble, Vermont	1
39.	Portland Blue Marble, Southerland Falls, Vt	1
40.	Lyonaise Marble, Vermont	1
41.	Lyonaise Marble, Vermont	1
42.	Lake Champlain Marble, Vermont	1
43.	Black Marble	1
44.	Pittsfield Blue Marble, Burlington Manufacturing Co	1
45.	American White Marble, Brandon, Vt	1
46.	Tennessee Marble, Knoxville, Tenn	1
47.	Serpentine Marble, Chester Co., Pa.	1
48.	Swanton Dove Marble, Vermont	1
49.	Swanton Dark Mottled Marble, Vermont	1
50.	LaPanto Marble	1
51.	Swanton Black Marble, Vermont	1
52.	American White Marble, Vermont	1
53.	Winooski Marble, Vermont	1
54.	Swanton Dove Marble, Vermont	1
55.	Swanton Gray Marble, Vermont	1
56.	Lyonaise Marble, Vermont	1
57.	Lyonaise Marble, Vermont	1
58.	Vermont Marble, Sutherland Falls, Vt	1
59.	St. Genevieve Sandstone, St. Genevieve, Mo	1

		No. of Specimens.
60.	Sandstone, Carroll Co., Mo	1
61.	St. Louis Limestone, Spencer, Ind	1
62.	Chester Sandstone, Orange Co., Ind	1
63.	Gray Granite, Hurricane Island, Me	1
64.	Gray Granite, Maine	1
65.	Black Diamond Granite, Maine	1
66.	Red Scotch Granite	1
67.	Clark's Island Granite, Rockland, Me.	1
68.	Gray Granite, Maine	1
69.	Gray Granite, Maine	1
70.	Gray Granite, Maine	1
71.	Gray Granite, Connecticut	1
72.	Oolitic Limestone, Kansas City, Mo	1
73.	Gray Granite, Maine	1
74.	Chester Sandstone, Orange Co., Ind	1
75.	Niagara Limestone, Lemont, Ill	1
76.	Plymouth Rock Granite, Hollowell, Maine.	1
77.	Lower Helderberg Limestone, Huntington, Ind	1
78.	Banded Iron Ore, Cedar Bluff, Warren Co., Ind	1
79.	Lithographic Limestone, Orange Co., Ind	1
80.	Corniferous Limestone, Dupont, Jefferson Co., Ind	1
81.	Corniferous Limestone, Dupont, Jefferson Co., Ind	1
82.	Oolitic Limestone, Salem, Ind	1
83.	Chalk-Carbonate Lime, Barber Co., Kas	1
84.	Blue Limestone, polished, locality unknown	1
85.	Limestone, polished, locality unknown	1
86.	Lithographic Limestone, Lawrence Co., Ind	1
87.	Shell Marble, Marble Hill, Jefferson Co., Ind	1
88.	Oolitic Limestone, Bedford, Ind	2
89.	Lower Helderberg Limestone, Wabash, Ind	1
90.	Lime Marl, Porter Co., Ind	1
91.	Oolitic Limestone, Spencer, Ind	1
92.	Black Roofing Slate, Monson, Me.	1
93.	Limestone, polished, Marble Hill, Jefferson Co., Ind	
94.	Black Roofing Slate, Monson, Me	1
95.	Sub-Carboniferous Sandstone, Berea, Ohio.	1
96.	Oolltic Limestone, Dark Hollow Quarry, Bedford, Ind	1
97.	Oolitic Limestone, Dark Hollow Quarry, Bedford, Ind	1
98.	Oolitic Limestone, Spencer, Owen Co., Ind	1
99.	Oolitic Limestone, Dark Hollow, Bedford, Ind	1
100.	Oolitic Limestone, Stone and Lime Co., Salem, Ind	1
101.	Oolitic Limestone, Dark Hollow, Bedford, Ind	1
102.	Verde Antique Marble	1

		No. of Specimens.
103.	Olive Champlain Marble, Swanton, Vt	1
104.	Pittsfield Blue Marble	1
105.	Tennessee Marble, Holston River.	1
106.	LaPanto Marble	1
107.	Lyonaise Marble, Vermont	1
108.	Red Granite, Missouri	1
109.	Hollowell Granite	1
110.	Hollowell Granite	1
111.	Niagara Limestone, Jefferson Co., Ind.	1
112.	Niagara Limestone, Jefferson Co., Ind.	1
113.	Oolitic Limestone, Corydon, Ind	1
114.	Freestone, Vanceburg, Ky	1
115.	Portland Cement, Shimi Bros., New Castle, Pa.	1
116.	Portland Cement, Shimi Bros., New Castle, Pa.	1
117.	Portland Cement, Shimi Bros., New Castle, Pa.	1
118.	Dark Chocolate Mottled Marble, Vermont	1
119.	Vermont White Marble.	1
120.	Tennessee Marble	1
121.	Chocolate Mottled Marble, Vermont	1
122.	White Tinted Marble, Vermont	1
123.	Black Marble, Glen's Falls, N. Y.	1
124.	Griolle Marble, Swanton, Vt	1
125.	LePanto Marble	1
126.	American White Marble, Vermont	1
127.	American Dark Blue Marble, Vermont	1
128.	Red Marble, Maine.	1
129.	Shell Marble, Tennessee.	1
130.	Lyonaise Marble, Vermont	1
131.	Swanton Black Marble, Vermont.	1
132.	LePanto Marble	1
133.	Dark Gray Marble, Tennessee	1
134.	Light Mottled LePanto Marble	1
135.	Dark Red LePanto Marble	1
136.	Light Gray Tennessee Marble	1
137.	Oolitic Limestone, polished, Bedford	1
138.	Black Roofing Slate, Morrison, Me	1
139.	Black Roofing Slate, Morrison, Me	1
140.	Oolitic Limestone, Spencer, Ind	1
141.	Cement and Lime, Shimi Bros., New Castle, Pa	1
142.	White Marble, Connecticut	1
143.	Lyonaise Marble, Vermont	1
144.	American Red Marble, Maine	1
145.	Shell Marble, Tennessee	1

		No. of Specimens.
146.	Chocolate Mottled Marble, Vermont	1
147.	Winooski Marble, Vermont	1
148.	Oolitic Limestone, Dark Hollow, Bedford	3
149.	Oolitic Limestone, Bedford, Ind	3
150.	Oolitic Limestone, Spencer, Ind	3
151.	Oolitic Limestone, Spencer, Ind	1
152.	Oolitic Limestone, Bloomington, Ind	1
153.	Oolitic Limestone, Gosport, Ind	1
154.	Oolitic Limestone, Spencer, Ind	1
155.	Oolitic Limestone, Putnamville, Ind	1
156.	Oolitic Limestone, Ellettsville, Ind	1
157.	Oolitic Limestone, Spencer, Ind	1
158.	Oolitic Limestone, Stinesville, Ind	1
159.	Oolitic Limestone, Bedford, Ind	1
160.	Oolitic Limestone, Bedford, Ind	3
161.	Niagara Limestone, Dayton, Ohio	2
162.	Niagara Limestone, St. Paul, Ind	1
163.	Niagara Limestone, Greensburg, Ind	1
164.	Niagara Limestone, Greensburg, Ind	1
165.	Niagara Limestone, Deputy, Ind	1
166.	Niagara Limestone, Deputy, Ind	1
167.	Niagara Limestone, Deputy, Ind	1
168.	Sub-Carboniferous Sandstone, Lorain Co., Ohio	1
169.	Sub-Carboniferous Sandstone, Grafton, Ohio	3
170.	Sub-Carboniferous Sandstone, Amherst, Ohio	1
171.	Sub-Carboniferous Sandstone, Grafton, Ohio	3
172.	Sub-Carboniferous Sandstone, Grafton, Ohio	3
173.	Sub-Carboniferous Sandstone, Sugar Grove, Ohio	3
174.	Sub-Carboniferous Sandstone, Berea, Ohio	3
175.	Oolitic Limestone, Spencer, Ind	1
176.	Oolitic Limestone, Dark Hollow, Bedford, Ind	1
177.	Oolitic Limestone, Dark Hollow, Bedford, Ind	1
178.	Oolitic Limestone, Bedford, Ind	1
179.	Niagara Limestone, Deputy, Ind	1
180.	Niagara Limestone, Deputy, Ind	1
181.	St. Louis Limestone, Putnamville, Ind	1
182.	Oolitic Limestone, Ellettsville, Ind	2
183.	Oolitic Limestone, Ellettsville, Ind	1
184.	Oolitic Limestone, Spencer, Ind	1
185.	Oolitic Limestone, Spencer, Ind	1
186.	Oolitic Limestone, Gosport, Ind	1
187.	Oolitic Limestone, Bloomington, Ind	1
188.	Oolitic Limestone, Bloomington, Ind	1

		No. of Specimens.
189.	Oolitic Limestone, Bedford, Ind	1
190.	Oolitic Limestone, Spencer, Ind	1
191.	Oolitic Limestone, Spencer, Ind	1
192.	Lake Superior Sandstone, Wisconsin	1
193.	Lake Superior Sandstone, Wisconsin	1
194.	Oolitic Limestone, Bedford, Ind	1
195.	Lake Superior Sandstone, Wisconsin	1
196.	Lithographic Limestone, Corydon, Ind	1
197.	Pure Portland Cement, Shimi Bros., New Castle, Pa	1
198.	Niagara Limestone, Lemont, Ill	1
199.	Oolitic Limestone, Bloomington, Ind	1
200.	Oolitic Limestone, Bloomington, Ind	1
201.	Oolitic Limestone, Gosport, Ind	1
202.	Corniferous Limestone, North Vernon, Ind	1
203.	Corniferous Limestone, North Vernon, Ind	1
204.	Oolitic Limestone, Stinesville, Ind	1
205.	Oolitic Limestone, Bedford, Ind	1
206.	Oolitic Limestone, Bedford, Ind	1
207.	Silurian Sandstone, Stony Point, Mich	1
208.	Sub-Carboniferous Blue Sandstone, Amherst, Ohio	1
209.	Sub-Carboniferous Sandstone, North Amherst, Ohio.	1
210.	Sub-Carboniferous Sandstone, Warrensburg, Mo	1
211.	Oolitic Limestone, Ellettsville, Ind	1
212.	Clonglomerate Sandstone, Attica, Ind	1
213.	Shell Marble, Marble Hill, Jefferson Co., Ind	1
214.	Corniferous Limestone, North Vernon, Ind	1
215.	Oolitic Limestone, Washington Co., Ind.	1
216.	Lower Helderberg Limestone, Kokomo, Ind	1
217.	St. Louis Limestone, Mitchell, Ind	1
218.	St. Louis Limestone, Cloverdale, Ind	1
219.	Lithographic Limestone, Orange Co., Ind	1
220.	Lithographic Limestone, Orange Co., Ind	1
221.	Corniferous Limestone, Logansport, Ind	1
222.	Devonian Sandstone, Kankakee, Ill.	1
223.	Oolitic Limestone, Spencer, Ind	1
224.	Chester Sandstone, Monroe Co., Ind	1
225.	Oolitic Limestone, Salem, Ind	1
226.	Vermont White Marble, Vermont	1
227.	Green Mottled Mariah Marble, Vermont	1
228.	Brown Tennessee Marble	1
229.	Griolle Marble, Vermont	1
230.	Pittsfield Blue Marble, Burlington, Manufacturing Co	1
231.	Oolitic Limestone, Baalbec Quarry, Bedford, Ind	1

		No. of Specimens.
232.	Oolitic Limestone, Baalbec Quarry, Bedford, Ind	1
233.	Oolitic Limestone, Baalbec Quarry, Bedford, Ind	1
234.	Oolitic Limestone, Bloomington, Ind	1
235.	Black Limestone, Warren Co., Ind	1
236.	Oolitic Limestone, Salem, Ind	1
237.	Oolitic Limestone, Salem, Ind	1
238.	Oolitic Limestone, Dark Hollow, Bedford, Ind	1

LIST OF LAND, FRESH AND SALT WATER SHELLS.

The following list includes all the land, fresh and salt water shells owned by the State. They are placed in cases temporarily, in the room intended for fossils exclusively, and numbered as in the list, but it is probable that we will soon be able to procure suitable cases for them in another part of the Museum, when they will be more perfectly classified and permanently placed. The shells, as a rule, are in an excellent state of preservation, and they are valuable aids to students in conchology who often visit the Museum for the purpose of studying the specimens and to secure assistance in identifying specimens collected in various parts of the State. There follows, also, a large list of duplicate shells, embracing several thousand specimens that are almost uniformly in a fine state of preservation.

Species in Case No. 1.

Case No.	Name.	No. of Specimens.
1.	*Vivipara contectoides*, W. G. Binney	25
2.	*Vivipara listeri*	7
3.	*Vivipara georgiana*, Lea	9
4.	*Vivipara subpurpurea*, Say	4
5.	*Vivipara texana*, Tryon.	3
6.	*Vivipara contecta*, Mill	3
7.	*Vivipara contecta*, Mill	6
8.	*Vivipara intertexta*, Say	5
9.	*Paludina fascia*, Mueller	8
10.	*Paludina vivipara*, Dinn	3
11.	*Paludina regularis*, Lea	2
12.	*Paludina genicula*, Conrad	4
13.	*Paludina chilinoides*, Reeve	2
14.	*Planorbis bicarinatus*, Say.	50
15.	*Planorbis bicarinatus*, Say.	34
16.	*Planorbis corneus*, DeKay.	4
17.	*Planorbis corpulentus*, Say.	2

Case No.	Name.	No. of Specimens.
18.	*Planorbis nitidus*, Mueller	50
19.	*Planorbis nitidus*, Mueller	5
20.	*Planorbis deflectus*, Say.	11
21.	*Planorbis complanatus*, Mueller	10
22.	*Planorbis albus*, Mueller	55
23.	*Planorbis albus*, Mueller	29
24.	*Planorbis spirorbis*, Mueller	30
25.	*Planorbis contortus*, Linnaeus	21
26.	*Planorbis glaboratus*, Say	8
27.	*Planorbis oregonensis*, Tryon	2
28.	*Planorbis opercularis*, Gould	8
29.	*Planorbis fontanus*, Montf	25
30.	*Planorbis exactus*, Say	31
31.	*Planorbis tumens*, Cooper	1
32.	*Planorbis parvus*, Say	25
33.	*Planorbis subcrenatus*, Cooper	2
34.	*Planorbis vermicularis*, Gould	25
35.	*Planorbis vortex*, Linneaus	4
36.	*Planorbis occidentalis*, Cooper	5
37.	*Planorbis ammon*, Gould	1
38.	*Planorbis rotundatus*, P.	24
39.	*Planorbis campanulatus*, Say	5
40.	*Planorbis trivolvis*, Say	10
41.	*Planorbis marginatus*, Draper	25
42.	*Planorbis acies*, Muhlf	20
43.	*Planorbis parvus*, Say	107
44.	*Pythia imbriacum*	6
45.	*Pythia argenvillei*, Pf.	6
46.	*Pythia McGillivrayi*, Pf.	5
47.	*Pythia pyramidata*, Reeve	1
48.	*Amnicola porata*, Say	107
49.	*Amnicola cincinnatiensis*, Anthony	105
50.	*Amnicola pallida*, Haldeman	12
51.	*Alexia berrundensis*, H. & A. Adams	3
52.	*Alexia bermudensis*, Adams	4
53.	*Alexia setifera*, Cooper	16
54.	*Alexia schæferi*, Cooper.	3
55.	*Bythinia rubens*, Menke	11
56.	*Bythinia tentaculata*, Linn	41
57.	*Anculosa rubiginosa*, Lea	5
58.	*Anculosa tryoni*, Lewis.	15
59.	*Anculosa zebra*, Anthony.	3
60.	*Anculosa foremanii*, Lea	2

Case No.	Name.	No. of Specimens.
61.	*Anculosa prærosa*, Say	14
62.	*Anculosa tintinabulum*, Lea	17
63.	*Anculosa downiei*, Lea	3
64.	*Anculosa plicata*, Conrad	4
65.	*Anculosa gibbosa*, Lea	4
66.	*Anculosa ligata*, Anthony	3
67.	*Anculosa tæniato*, Conrad	3
68.	*Anculosa formosa*, Lea	3
69.	*Anculosa costata*, *Say*, *trilineata*, Anthony	22
70.	*Anculosa ampla*, Anthony	4
71.	*Goniobasis haysiana*, Lea	11
72.	*Goniobasis vanuxemensis*, Lea	14
73.	*Goniobasis occata*, Hinds	4
74.	*Goniobasis rubicunda*, Lea	4
75.	*Goniobasis variata*, Lea	22
76.	*Goniobasis gerhardtii*, Lea	1
77.	*Anculosa subglobosa*, Say	15
78.	*Anculosa coosænsis*, Lea	3
79.	*Anculosa flammata*, Lea	2
80.	*Anculosa picta*, Conrad	10
81.	*Anculosa vittata*, Lea	3
82.	*Anculosa virgata*, Lea	6
83.	*Anculosa contorta*, Lea	4
84.	*Anculosa tuberculata*, Lea	2
85.	*Anculosa elegans*, Anthony	4
86.	*Anculosa carinata*, Brug	8
87.	*Goniobasis boykinianus*, Lea	1
88.	*Goniobasis arachnoidea*, Anthony	8
89.	*Goniobasis draytonii*, Lea	7
90.	*Goniobasis propinqua*, Lea	4
91.	*Goniobasis carinifera*, Lamark	15
92.	*Goniobasis edgariana*, Lea	24
93.	*Goniobasis castanea*, Lea	26
94.	*Goniobasis mutabilis*, Lea	5
95.	*Goniobasis plicifera*, Lea	5
96.	*Goniobasis cristata*, Anthony	2
97.	*Goniobasis semicarinata*, Say	10
98.	*Goniobasis shastænsis*, Lea	2
99.	*Goniobasis bella*, Conrad	4
100.	*Goniobasis instabilis*, Lea	12
101.	*Goniobasis symmentrica*, Haldem	2
102.	*Goniobasis aterina*, Lea	20
103.	*Goniobasis catenoides*, Lea	2

Case No.	Name.	No. of Specimens.
104.	*Goniobasis cylindracea*, Conrad	4
105.	*Goniobasis porrecta*, Lea	27
106.	*Goniobasis olivata*, Conrad	8
107.	*Goniobasis granata*, Lea	2
108.	*Goniobasis canbyi*, Lea	13
109.	*Goniobasis smithsoniana*, Lea	2
110.	*Goniobasis acuto-carinatus*, Lea	11
111.	*Goniobasis ovalis*, Lea	4
112.	*Goniobasis continens*, Lea	1
113.	*Goniobasis nigrina*, Lea	15
114.	*Goniobasis varians*, Lea	1
115.	*Goniobasis pudica*, Lea	5
116.	*Goniobasis virginica*, Gmelin	1
117.	*Goniobasis costifera*, Haldem	1
118.	*Goniobasis livescens*, Menke	29
119.	*Goniobasis coosaensis*, Lea.	4
120.	*Goniobasis murrayensis*, Lea	3
121.	*Goniobasis pinpaeformis*, Lea	3
122.	*Goniobasis papillosa*, Anthony	92
123.	*Goniobasis laeta*, Say.	4
124.	*Goniobasis depygis*, Say.	52
125.	*Goniobasis troostiana*, Lea.	27
126.	*Hybrids between Goniobasis virginica*, Gmelin & *G. livescens*	7
127.	*Pomatias patulum*, Dop.	47
128.	*Pomatias pabulum*, Dop	131
129.	*Pomatias septemspirale*, Razoum	34
130.	*Pomatias tessatatus*, Wright	2
131.	*Segmentina armigera*, Say.	28
132.	*Tryonia protea*, Gould	20
174.	*Amycla gausapata*, Gask	2
175.	*Chorostoma funebrale*, A. Adams	1
176.	*Lioplax subcarinata*, Say	18
177.	*Binnea notabalis*, Cooper	3
178.	*Ariolomax columbianus*, Gould	1
179.	*Oleacina venusta*, C. B. Adams	32
180.	*Oleacina ceylonica*	8
181.	*Torquilla secola*, Draper	22
182.	*Torquilla frumentum*, Draper	64
183.	*Torquilla avenacea*, Brug	4
184.	*Prophysaon hemphilli*, Bl. & Bin	3
185.	*Subulina octona*, Chemitz	8
186.	*Tebennophorus carolinensis*, Bosc	3
187.	*Tebennophorus carolinensis*, Bosc	6

Case No.	Name.	No. of Specimens.
188.	*Balea fragilis*, Draparnaud	11
189.	*Melania virgata*, Lea.	18
190.	*Melania tenuisulcata*, D. Kr.	1
191.	*Melania holandri*, Fer	8
192.	*Melania argillierti*, Phl.	2
193.	*Melania virginica*	46
194.	*Achatina fulva*, Brug	1
195.	*Achatina fasciata*, Mueller	2
196.	*Achatina tessellata*, Newc	1
197.	*Achatina vitrea*, Newc	1
198.	*Achatina tœniolata*, Pfe	2
199.	*Achatina ventulus*, Ferussac	2
200.	*Achatina perdix*, Reeve	2
201.	*Achatina nubilosa*, Migh	2
202.	*Achatina mighelsiana*, Pfr.	1
203.	*Achatina turritella*, Fer.	2
204.	*Achatina polita*, Reeve	1
205.	*Achatina tristis*, Fer	2
206.	*Achatinella vulpina*, Fer	4
207.	*Achatinella mastersi*, Newc	1
208.	*Achatinella sanguinea*, Newc.	2
209.	*Achatinella bucca*, Reeve	2
210.	*Achatinella elegans*, Newc	1
211.	*Achatinella variabilis*, Newc	3
212.	*Achatinella biplicata*, Newc	2
213.	*Achatinella straminea*, Reeve	1
214.	*Achatinella porphyrea*, Newc	1
215.	*Achatinella viridans*, Migh	2
216.	*Achatinella recta*, Newcomb	3
217.	*Achatinella swiftii*, Newcomb	2
218.	*Achatinella producta*, Reeve	2
219.	*Achatinella picta*, Mighel	2
220.	*Achatinella guttula*, Newcomb	2
221.	*Achatinella bilineata*, Reeve	3
222.	*Achatinella humilis*, Reeve	2
223.	*Achatinella baldwini*, Newcomb	2
224.	*Achatinella fumosa*, Newcomb	2
225.	*Achatinella decora*, Fer	1
226.	*Achatinella bulimoides*, Swains	1
227.	*Achatinella virgulata*, Migh	2
228.	*Achatinella lorata*, Fer	2
229.	*Achatinella nitida*, Newc	3
230.	*Achatinella modesta*, C. B. Adams	2

Case No.	Name.	No. of Specimens.
231.	*Achatinella melanostoma*, Newcomb	1
232.	*Achatinella nigra*, Pfe	1
233.	*Achatinella abbreviata*, Reeve	
234.	*Achatinella mustelina*, Mighel	4
235.	*Achatinella plicata*, Mighel	2
236.	*Cyclostoma zanguebarica*, Pfr	6
237.	*Cyclostoma sulcatum*, Lamark	5
238.	*Cyclostoma catenatum*, Gould	9
239.	*Cyclostoma jayanus*, C. B. Adams	9
240.	*Cyclostoma rugulosum*, Pfe	10
241.	*Cyclostoma sagra*, D. Orb	3
242.	*Cyclostoma browni*, C. B. Adams	3
243.	*Cyclostoma chevalieri*, C. B. Adams	3
244.	*Cyclostoma elegans*, Mueller	25
245.	*Cyclostoma chrysoraphe*, Sowerby	4
246.	*Cyclostoma olivieri*, Sowerby	2
247.	*Cyclostoma banksiana*, Sowerby	6
248.	*Buliminus detritus*, Mueller var., *radiatus*, Brug	6
249.	*Buliminus towinefortianus*, Fer	2
250.	*Buliminus montanus*, Draper	9
251.	*Bulinus acuta*, Draper	4
252.	*Bulinus hypnorum*, Linnaeus	20
253.	*Succinea campestris*, Say	7
254.	*Succinea luteola*, Gould	2
255.	*Succinea effusa*, Shuttleworth	1
256.	*Succinea obliqua*, Say	18
257.	*Succinea amphibia*, Pfe	31
258.	*Succinea rusticana*, Gould	4
259.	*Succinea concordialis*, Gould	1
260.	*Succinea oblonga*, Draper	16
261.	*Succinea oregonensis*, Lea	71
262.	*Succinea avara*, Say	7
263.	*Succinea effusa*, Shuttleworth	19
264.	*Succinea ovalis*, Gould	21
265.	*Succinea aurea*, Lea	47
266.	*Succinea totteniana*, Lea	5
267.	*Succinea vermeta*, Say	4
268.	*Succinea illinoisensis*, Wolf	13
269.	*Succinea pfeifferi*, Rossm	33
270.	*Succinea sillimani*, Bland	8
271.	*Succinea muttalliana*, Lea	5
272.	*Vertigo ventricosa*, Morse	50
273.	*Vertigo gouldi*, Binney	2

Case No.	Name.	No. of Specimens.
274.	*Vertigo doliolum*, Brug	2
275.	*Vertigo tridentata*, Wolf	3
276.	*Vertigo antivertigo*, Draper	20
277.	*Vertigo pygmæa*, Draparnaud	40
278.	*Vertigo ovata*, Say.	115
279.	*Vertigo substriata*, Pfr	4
280.	*Vertigo simplex*, Gould	2
281.	*Vertigo pusilla*, Mueller	15
282.	*Vertigo pagodula*, Desm	5
283.	*Neritina cummingiana*, Resl	40
284.	*Neritina mertoniana*, Rec	75
285.	*Neritina cornea*, Linnaeus	5
286.	*Neritella reclivata*, Say	30
287.	*Neritina muratilis*, Lamark	28
288.	*Neritina matronis*, Reeve	14
289.	*Neritina danubialis*, Pf. (?), var. *carinata*, Kok.	7
290.	*Neritina fluviatilis*, Linn	47
291.	*Neritina virginea*, Lea	4
292.	*Neritina valentina*, Gr	2
293.	*Neritina halophila*, Kl	27
294.	*Limnæa tumida*, Held	7
295.	*Limnæa palustris*, Mueller	29
296.	*Limnæa palustris*, Mueller	5
297.	*Limnæa reflexa*, Say	2
298.	*Limnæa turricula*, Held	22
299.	*Limnæa ampla*, Mighels	6
300.	*Limnæa ampla*, Mighels	12
301.	*Limnæa auricularia*, Linn., var. *ampla*, Harton	3
302.	*Limnæa auricularia*, Linn	3
303.	*Limnæa stagnalis*, Linn	2
304.	*Limnæa stagnalis*, Linn	25
305.	*Limnæa stagnalis*, Linn	14
306.	*Limnæa peregra*, Mueller	14
307.	*Limnæa truncatula*, Mueller	25
308.	*Limnæa rosea*, Gat	22
309.	*Limnæa rowelli*, Tryon	14
310.	*Limnæa caperata*, Say	16
311.	*Limnæa humilis*, Say	29
312.	*Limnæa ovata*, Draper	6
313.	*Limnæa fragilis*, Linnaeus	3
314.	*Limnæa corvus*, Gmelin	3
315.	*Limnæa hypnorum*, Linn	26
316.	*Limnæa haydeni*, Lea	8

Case No.	Name.	No. of Specimens.
317.	*Limnæa bulimoides*, Lea	13
318.	*Limnæa nubella*, Clessin	10
319.	*Limnæa columella*, Say	21
320.	*Limnæa adelinæ*, Tryon	7
321.	*Limnæa catascopium*, Say	25
322.	*Limnæa undulata*, Say	2
323.	*Limnæa minuta*, Draparnaud	3
324.	*Limnæa campestris*, Bin.	15
325.	*Limnæa abrussa*, Say	3
326.	*Limnæa glabra*, Mueller	3
327.	*Limnæa elongata*, Draper	3
328.	*Limnæa gracilis*, Jay	1
329	*Limnæa peregra*, Draper, var. minor	12
330.	*Limnæa binneyi*, Tryon	4
331.	*Limnæa traskii*, Tryon	7
332.	*Physa sayii*, Tappan	3
333.	*Physa costata*, Newcomb	4
334.	*Physa traskii*, Lea	3
335.	*Physa diaphana*, Tryon	6
336.	*Physa bahiensis*, Mex.	3
337.	*Physa anatina*, Lea	3
338.	*Physa sparsestriata*, Tryon	3
339.	*Physa showalteri*, Lea	2
340.	*Physa d'orbigni*, Lea	10
341.	*Physa heterostropha*, Say	33
342.	*Physa lordii*, Baird	12
343.	*Physa braziliensis*, Anthony	6
345.	*Physa ancillaria*, Say	7
346.	*Physa gabbi*, Tryon	4
347.	*Physa gyrina*, Say	26
348.	*Physa gyrina*, Say, *hildrethiana*, Lea	1
349	*Physa microstoma*, Haldeman	46
350.	*Macroceramus goosei*, Pfe	2
351.	*Macroceramus claudens*, Gundlach	2
352.	*Macroceramus microdon*, Pfe	7
353.	*Macroceramus parallelus*, Araugo	2
354	*Cochlicella conoidea*, Dek	1
355.	*Megalomastoma cylindracrum*, Chemnitz	2
356.	*Anisus marginatus*, Dra	11
357.	*P.* ——, Species	1
358.	*Paludinella schmidtii*, Cha	3
359.	*Paludinella dunkeri*	30

Case No.	Name.	No. of Specimens.
360.	*Carychium exiguum*, Say	250
361.	*Carychium minim*, Mueller	25
362.	*Cionella acicula*, Mueller	7
363.	*Cionella lubrica*, Mueller	50
364.	*Cionella subcylindrica*, Linn	47
365.	*Cionella acicula*, Mueller	2
366.	*Chondropoma newcombiana*, C. B. Adams	8
367.	*Chondropoma rubicundum*, Moricand	6
368.	*Chondropoma santacruzensis*, Pfe	9
369.	*Chondropoma sanvallei*, Gand	4
370.	*Chondropoma pictum*, Pfeiffer	5
371.	*Melanopsis prærosa*, Linn	5
372.	*Melanopsis braziliensis*, Mer	3
373.	*Melampus coffea*, Linn	2
374.	*Melampus olivaceus*, Cooper	8
375.	*Melampus bidentatus*, Say	5
376.	*Amphipeplia glutinosa*, Mueller	2
377.	*Schasicheila alata*, Shuttle.	2
378.	*Carinifex newberryi*, Lea	12
379.	*Registoma grande*, Gray	2
380.	*Registoma complanata*, Pease	4
381.	*Bythanella obtusa*, Lea	1
382.	*Acanthinula aculeata*, Mueller	2
383.	*Adamsiella ignilabris*, C. B Adams	3
384.	*Adamsiella grayana*, Pfr	3
385.	*Adamsiella variabilis*, Adams	15

List of Shells in Case No. 2.

1.	*Pomus depressa*, Say	7
2.	*Ampullaria urceus*, Mueller	1
3.	*A. globosa*, Saus	1
4.	*A. decassata*, Mos	2
5.	*A. fasciata*, Lamarck	3
6.	*A. scalaris*, D. Orb	1
7.	*A.* ———, Species	1
8.	*Lanestes lubica*, Horel	2
9.	*Melantho decisa*, Say	30
10.	*M. integra*, Say	6
11.	*M. decisa* (*var. subsolidus*), Say	7
12.	*M. ponderosa*, Say	9
13.	*M. decisa* (*var. obesa*), Say	20
14.	*Bulinus ablus*, Sowerby	2

Case No.	Name.	No. of Specimens.
15.	*B. shongii*, Lea	1
16.	*B. largillierti*, Phil	2
17.	*B. citrinus*, Brug	1
18.	*B. bilobatus*, Brod.	2
19.	*B. ovoideus*, Brug	2
20.	*B. cincinnus*, Sowl	2
21.	*B. glotus*, Gmel.	1
22.	*B. luzonicus*, Sow	1
23.	*B. auris-muris*, Moricand.	1
24.	*B. nympha*, Pfe.	1
25.	*B. perversus*, Hay.	1
26.	*Bulimus oblongus*, Mueller	1
27.	*B. proximus*, Sow	1
28.	*B. ovatus*, Brug	1
29.	*B. glaber*, Gme	2
30.	*B. glaber*, Gme	4
31.	*B. peruvianus*, Brug	2
32.	*B. detritus*, Mueller	8
33.	*B. distortus*, Brug	1
34.	*B. sylvanus*, Broder	1
35.	*B. tenuissimus*, Ter	5
36.	*B. tasmanicus*, Pfe.	2
37.	*B. tridens*, Mueller	13
38.	*B. niso*. Risso	2
39.	*B. microtragus*, Parreyo	3
40.	*B. angiostomus*, Wagner	1
41.	*B. obscurus*, Mueller.	12
42.	*B. sepulchratus*, Poey	6
43.	*B. histrio*	——
44.	*Lythoglyphus naticoides*, Ter	——
45.	*Trypanostoma alveare*, Conrad	52
46.	*T. bivittatum*, Lea	3
47.	*T.* ——(?), Lewis	3
48.	*T. venustum*, Lea	15
49.	*T. annuliferum*, Conrad	3
50.	*T. pybasii*, Lea.	13
51.	*Trypanostoma vestitum*, Conrad	2
52.	*T. dux*, Lea	4
53.	*T. nobile*, Lea	17
54.	*T. opaca*, Anthony	5
55.	*T. alabamense*, Lea	8
56.	*T. christyi*, Lea.	3
57.	*T. canaliculatum*, Say	38

Case No.	Name.	No. of Specimens.
58.	*T. conicum*, Say	40
59.	*T. simplex*, Lea	2
60.	*T. prasinatum*, Conrad	6
61.	*T. tuomeyi*, Lea.	2
62.	*T. excuratum*, Con	6
63.	*T. gradatum*, Anthony	9
64.	*T. spillmanii*, Lea.	4
65.	*T. vividulum*, Anthony	3
66.	*T. troostii*, Lea	2
67.	*T. canalitium*, Lea	4
68.	*T. torquatum*, Lea.	3
69.	*T. conradi*, Tyron	9
70.	*T. neglectum*, Anthony.	7
71.	*T. estabrookii*, Lea.	9
72.	*T. undulatum*, Say	38
73.	*T. fastigiatum*, Anthony	8
74.	*T. strigosum*, Lea	7
75.	*Trypanostoma aratum*, Lea	1
76.	*T. schowalterii*, Lea	4
77.	*T. subulare*, Lea	22
78.	*T. unciale*, Halden	12
79.	*T. mucronatum*, Lea	4
80.	*T. viride*, Lea	5
81.	*T. modesta*, Lea.	4
82.	*T. clarkii*, Lea	2
83.	*T. parvum*, Lea.	21
84.	*T. ponderosa*, Say	19
85.	*T. lyonii*, Lea	11
86.	*T. robusta*, Lea	8
87.	*T. nodosum*, Lea	11
88.	*T. moniliferum*, Lea	32
89.	*T. jayi*, Lea	6
90.	*T.* —— (?), Lea	7
91.	*T. chackasahaense*, Lea	6
92.	*T. ligatum*, Lea.	4
93.	*T. leai*, Tryon	2
94.	*T. validum*, Anthony	5
95.	*T. anthonyi*, Lea	3
96.	*T. filum*, Lea.	5
97.	*T. trivittatum*, Lea	4
98.	*T. plicatum*, Tryon	20
99.	*Trypanostoma stratum*, Lea	2
100.	*T. attenuatum*, Lea	4

Case No.	Name.	No. of Specimens.
101.	*T. affine*, Lea	1
102.	*T. moriforme*, Lea.	7
103.	*T. knoxvillense*, Lea	4
104.	*T. foremanii*, Lea	4
105.	*T. whitei*, Lea	4
106.	*T. thorntonii*, Lea	5
107.	*T. incurvum*, Lea	19
108.	*Gongylostoma strigosum*, Lea	4
109.	*G. impressa*, Lea	4
110.	*G. laeta*, Say	4
111.	*G. sparus*, Lea	8
112.	*G. crebricostata*, Lea	7
113.	*Angitrema salebrosa*, Conrad	6
114.	*A. parva*	3
115.	*A. verrucosa*, Rof	50
116.	*A. nupera*, Rof	80
117.	*A. geniculata*, Holden	13
118.	*A. armigera*, Say	18
119.	*A. wheatleyi*, Tryon	13
120.	*A. jayana*, Lea	7
121.	*A. duttoniana*, Lea	9
122.	*Lithasia fuliginosa*, Lea	8
123.	*Lithasia brevis*, Lea	2
124.	*L. fisiformis*, Lea	6
125.	*L. nuclea*, Lea	3
126.	*L. schowalterii*, Lea	11
127.	*L. vittata*, Lea	2
128.	*L. nucleola*, Anthony	6
129.	*L. obovata*, Say	30
130.	*L. wheatleyi*, Lea	4
131.	*Tulotoma augulata*, Lea.	7
132.	*T. magnifica*, Conrad	12
133.	*Strephobasis Clarkii*, Lea	9
134.	*S. cornea*, Lea	6
135.	*S. plena*, Anthony	9
136.	*S. lyoni*, Lea	7
137.	*S. corpulenta*, Lea.	4
138.	*S. solida*, Lea	7
139.	*S. olivaria*, Lea	7
140.	*Eurycoleon crassa*, Hald	2
141.	*E. anthonyi*, Redfield	4
142.	*E. lepida*, Lea	3
143.	*E. gibberosa*, Lea	16

Case No.	Name.	No. of Specimens.
144.	*Schizostoma glandulum*, Lea	2
145.	*S. quadratum*, Anthony	3
146.	*S. wetumpkaemse*, Lea	6
147.	*Schizostoma incisum*, Lea	6
148.	*S. salebrosum*, Lea	2
149.	*S. cariniferum*, Lea	5
150.	*S. alabamaense*, Lea	4
151.	*S. punulum*, Lea	2
152.	*S. hartmanii*, Lea	2
153.	*S. lewisii*, Lea	2
154.	*S. excisa*, Lea	2
155.	*S. constrictum*, Lea	2
156.	*S. recta*, Anthony	1
157.	*S. demissum*, Anthony	2
158.	*S. amplum*, Anthony	2
159.	*S. bulbosum*, Anthony	3
160.	*S. virens*, Lea	2
161.	*S. globosum*, Lea	1
162.	*S. ornatum*, Anthony	2
163.	*S. glans*, Lea	2
164.	*S. robustum*, Lea	2
165.	*S. ovale*, Anthony	2
166.	*S. ellipticum*, Lea	3
167.	*S. castaneum*, Lea	2
168.	*Somatogyrus subglobosus*, Say	50
169.	*S. cuvierianus*, Lea	8
170.	*S. isogomus*, Say	60
171.	*Somatogyrus amens*, Lea	163
172.	*Hydrobia octona*, Nillson	5
173.	*H. sylvae*, Pumant	7
174.	*H. baltica*, Willsón	261
175.	*H. pygmæa*, Dunk	200
176.	*Anclus fluviatilus*, Linn	30
177.	*A. fluviatilus, var. gopustina*	15
178.	*A. lacustris*, Linn	7
179.	*A. contortus*, Linn.	1
180.	*A. fuscus*, Adams	25
181.	*Trypanostoma postellii*, Lea	11
182.	*T. pictum*, Lea	4
183.	*Truncatella californica*, Pfe	9
184.	*T. bilabiata*, Pfe	3
185.	*T. stimpsonii*, Stearns	9
186.	*Holospera pilocera*, Pfe	1

Case No.	Name.	No. of Specimens.
187.	*Stoastoma, pisum*, C. B. Adams	2
188.	*Mc. lanopsis muraldi*, Ziegler	12
189.	*Physopsis africana*, Krauss	2
190.	*Polomides scalariformis*, Brong	8
191.	*Fluminicola nuttalliana*, Lea	18
192.	*F. virens*, Lea	4
193.	*Limax campestris*, Binney	7
194.	*Limax campestris*, Binney	19
195.	*Limax campestris*, Binney	17
196.	*Patula nodosa*, Pfe	2
197.	*Partula gibba*, Ferussac	2
198.	*P. lutea*, Lesson	1
199.	*P. sirata*, Mousson	1
200.	*P. rectuziana*, Petit	1
201.	*P. striolata*, Pease	1
202.	*P. compressa*, Pfe	1
203.	*P. varia*, Broderich	2
204.	*P. planilabrum*, Pease	1
205.	*P. variabilis*, Pease	2
206.	*P. guamensis*, Pfe	2
207.	*P. mastersi*, Pfe	3
208.	*P. rosea*, Brod	1
209.	*P. simulans*, Pease	1
210.	*P. hyalina*, Brod	3
211.	*P. glutinosa*, Pfe	3
212.	*P. vexillum*, Pease	3
213.	*P. hebe*, Pfe	2
214.	*Tudora megacheila*, P. & M	20
215.	*Partula lineolata*, Pease	2
216.	*P. faba*, Mort	2
217.	*P. rubescens*, Pease	2
218.	*P. affinis*, Pease	1
219.	*P. lugubris*, Pease	1
220.	*Partula trilineata*, Pease	2
221.	*P. terrestris*, Pease	1
222.	*P. filosa*, Pfe	1
223.	*P. elongata*, Pease	1
224.	*P. assimilis*, Pease	1
225.	*P. bicolar*, Pease	2
226.	*Tudore augusta*, Adams	6
227.	*T. fecunda*, B. Ad.	2
228.	*T. armata*, Adams	4
229.	*T. versicolor*, Pfe	11

Case No.	Name.	No. of Specimens.
230.	*Clausila itala*, Menke	7
231.	*C. rugoso*, Draper	9
232.	*C. bielzii*, Pfe	3
233.	*C. braunii*, Chrp	10
234.	*C. regalis*, Parr	7
235.	*C. lischeana*, Parr. (Var. *livescens*, Parr)	5
236.	*C. dalmatina*, Parr	3
237.	*C. data*, Ziegler	7
238.	*C. fimbriata Var. gottsche*, Muhl	5
239.	*C. alboguttulata*, Wagner	7
240.	*C. bergeri*, Mayer	11
241.	*C. ornata*, Ziegler	5
242.	*C. bidens*, Draparnand	2
243.	*C. fimbriata*, Muhl	12
244.	*Clausila plicatula*, Drap. (Var. *major*)	2
245.	*C. straminicollis*, Parr	5
246.	*C. aquilla*, Parr.	6
247.	*C. dacica*, Fri	3
248.	*C. nigricans*, M. & E	5
249.	*C. laminata*, Montague	21
250.	*C. similis*, Chrp	51
251.	*C. biplicata*, Montf	44
252.	*C. plicata*, Draper.	31
253.	*C. fitograna*, Ziegler	3
254.	*C. papillaris*, Muller.	13
255.	*C. cattaroensis*, Zieg	3
256.	*C. dubia*, Draper	11
257.	*C. parvula*, Studer	94
258.	*C. orthostoma*, Mke	47
259.	*C. decipiens*, Rossm	3
260.	*C. decipiens, var. latilabris*, Ross, Wag	
261.	*C. ventricosa*, Draper.	10
262.	*C. ventricosa* (*Var. minor*), Draper.	2
263.	*C. draparnaldi Beck, cingata*, Draper	2
264.	*C. plicatula*, Draper	131
265.	*C. fallax*, Rossm	11
266.	*C. lischkeana*, Parr.	13
267.	*C. densestriata*, Ziegler	2
268.	*Clausilia lævissima*, Ross	10
269.	*C. lineolata*, Steward.	45
270.	*C. fussiana*, Birtz	4
271.	*C. pumila*, Ziegler.	10
272.	*C. plumbea*, Roosm	23

Case No.	Name.	No. of Specimens.
273.	*C. plumbea* (*Var. cornea*), Ross	2
274.	*C. laminata* (*Var. cingulata*), Montf	5
275.	*C. plicatula* (*Var. minor*), Drap	9
276.	*C. madensis*, Ter	6
277.	*C. tridens*, Ch	7
278.	*C. livida*, Menke	4
279.	*C. cana*, Held	45
280.	*C. succineata* (*Var. lasica*), Ziegler	10
281.	*C. succineata* (*Var. corpulenta*), Ziegler	4
282.	*C. ioes*, Benson	1
283.	*C. albicilla*, Ziegler	3
284.	*C. phillippiana*, Pfe	3
285.	*C. lactea*, Biebe	3
286.	*C. olivieri*, Roth	5
287.	*C. conspurgata*, Draper	4
288.	*Baleo-Clausilia haneri*, Blg	2
289.	*Clausilia cruciata*, Studer	14
290.	*C. gracilis*	15
291.	*Cylindrella seminuda*, C. B. Adams	5
292.	*Cylindrella chordata*, Pfe	14
293.	*C. morini*, Morse	5
294.	*C. fastigiata*, Gdlch	6
295.	*C. elliottii*, Poey	1
296.	*C. sowerbyana*, Pfe	1
297.	*C. elongata*, Chem.	13
298.	*C. goldfussi*, Mke	4
299.	*C.* ——, Poey	1
300.	*C. augusta*, Wright	6
301.	*C. striatella*, Wright	1
302.	*C. coronadoi*, Arrango	2
303.	*C. vignalensis*, Wright	2
304.	*C. pallida*, Guild	7
305.	*C. brooksiana*, Gd	3
306.	*C. perlata*, Gould	3
307.	*C. lateralis*, Pay	2
308.	*C. soluta*, Pfe	1
309.	*C. sanguinea*, Pfe	9
310.	*C. rosea*, Pfe	2
311.	*C. humboltiana*, Pfe	1
312.	*C. fabreana*, Poey	1
313.	*C. lavelleana*, D. Orb	6
314.	*C. maugeri*, Wood	15
315.	*Cylindrella gracilis*, Wood	11

Case No.	Name.	No. of Specimens.
316.	*C. brevis*, Pfe.	11
317.	*C. jejuna*, Gould	2
318.	*C. sexdecimalis*, Sim	2
319.	*C. torquata*, Moril	1
320.	*C. crenata*, Pfe	2
321.	*C. hollandi*, Adams	3
322.	*C. collaris*, Ter	3
323.	*C. inornata*, Gdluch	2
324.	*Pupa californica*, Rowell	65
325.	*P. avenacea*, Brug	31
326.	*P. contracta*, Say	120
327.	*P. muscorum*, Linn	75
328.	*P. inornata*, Mueller	60
329.	*P. megacheilos*, Jan., var. *tricolor*, Villa.	13
330.	*P. minutissima*, Hartman	55
331.	*P. umbilicola*, Draper	2
332.	*P. corticaria*, Say	75
333.	*P. secale*, Draparnaud	4
334.	*P. armifera*, Say	89
335.	*P. phillippi*, Cants	4
336.	*P. gularis*, Rossm	3
337.	*P. pentodon*, Say	20
338.	*Pupa vowellii*, Newcomb	8
339.	*P. muscorum*, Linn	30
340.	*P. secale*, Draparnand	18
341.	*P. cinerea*, Draparnand	9
342.	*P. fallax*, Say	207
343.	*P. incana*, Binney	1
344.	*P. rupicola*, Say.	125
345.	*P. palanga*, Leffon	1
346.	*P. maritima*, Pfe	1
347.	*P. bryanti*, Pfe	3
348.	*P. arizonensis*, Gobb.	2
349.	*P. furca*, Hartmann	9
350.	*Strophea iostoma* (*Var. inagua*), Pfe	5
351.	*S. ava*, Linneana	13
352.	*Cylindria scalarina*, Shuttle	3
353.	*Euhyalina cellaria*, Muller	2
354.	*E. nitidula*, Draper	5
355.	*E. malinowskii*, Zeleb	2
356.	*E. crystallina*, Muller	15
357.	*E. nitida*, Muller	8
358.	*E. para*, Alder	15

Case No.	Name.	No. of Specimens.
359.	*E. nitens*, Muller	6
360.	*E. lucida*, Draper.	5
361.	*Valvata piscinalis*, Muller.	9
362.	*Valvata crustata*, Muller	104
363.	*V. arenifera*, Lea	84
364.	*V. contora*, Muller	27
365.	*V. virens*, Tryon	4
366.	*V. tricarinata*, Say	75
367.	*V. alpestris*, Plan	3
368.	*Pedipes unisulcata*, Cooper	1
369.	*Io recta*, Autte	4
370.	*Io gibbosa*, Autte	4
371.	*Io spinosa*, Lea	7
372.	*Io fluvialis*, Say	4
373.	*Io rhomboidea*.	3
374.	*Io turrita*, Anthony	2
375.	*Paludomus loricatus*, Reeve	3
376.	*Ceritheum montaguei*, D. Orb	3
377.	*Tomocyclus geatei*, Cross and F	2
378.	*Hernisium behni*, Reeve	3
379.	*Polamides, fuscatum*, Linn	4
380.	*Pleurocera lesleyi*, Lea	2
381.	*Pomatiopsis cincinnatiensis*, Lea	59
382.	*P. intermedia*, Tryon	24
383.	*P. lapidaria*, Say	84
384.	*Cistula rufilabre*, Beck	4
385.	*C. radiosa*, Mor.	2
386.	*Cistula grabeloupi*, Pfe	1
387.	*C. bilabris*, Menke	7
388.	*C. rufilabre*, Beck	12

Shells in Case No. 3.

1.	*Helix multilineata*, Say	40
2.	*H. poaliosa*, B. Ad	1
3.	*H. ghiesbreghli*, Nyst	1
4.	*H. straminea*, Brug	1
5.	*H. jamaicus*, Chemnitz	2
6.	*H. lactea*, Muller	2
7.	*H. auricoma*, formo	3
8.	*H. crispata*, Lea	2
9.	*H. spiriosa*, Say	1
10.	*H. haemostoma*, Linn	1

Case No.	Name.	No. of Specimens.
11.	*H. pomalia*, Linneus	3
12.	*H. carocolla*, Linneus	3
13.	*H. exoleta*, Binney	40
14.	*H. thyroides*, Say	38
15.	*H. cicatricosa*, Bern	1
16.	*H. grisea*, Muller	2
17.	*H. arrosa*, Gould	4
18.	*H. acuta*, Lamarck	3
19.	*H. pouzalzi*, D	2
20.	*H. tukanensis*, Pf	4
21.	*H. haemastoma*, Linn	1
22.	*H. infumata*, Gould	2
23.	*H. aspersa*, Muller	6
24.	*H. cincta*, Muller	3
25.	*H. melanostoma*, D'p	2
26.	*Helix* (*Nanina*) *citrina*, Linn.	2
27.	*H. tudiculata*, Binney	5
28.	*H. solitaria*, Say	32
29.	*H.* (*Triodopsis*) *tridentata*, Say	71
30.	*H. major*, Binney	2
31.	*H. lais*, Pf.	3
32.	*H. discolor*, Ter.	1
33.	*H.* (*Arionta*) *townsendiana*, Lea	4
34.	*H. marginella*, Genet	2
35.	*H. exavata*, Pf.	2
36.	*H. fidelis*, Gray	3
37.	*H lucerna*, Muller	1
38.	*H. spiriplana*, Olivier	2
39.	*H. vindobonensis*, Pf.	3
40.	*H. traski*, Newcomb.	8
41.	*H. sophia*, Gaskoin	1
42.	*H. infumescus*	1
43.	*H. planulata*, Lamarck	1
44.	*H. alternata*, Say	39
45.	*H. appressa*, Say	56
46.	*H. loricata*, Gould	8
47.	*H. ericetorum*, Mueller.	15
48.	*H. descitorum*, Forskal	1
49.	*H. bulweriana*, Lowe	2
50.	*Helix varians*, Menke	2
51.	*H. incerta*, For	4
52.	*H. figulina*, Parr	1
53.	*H. carthusiana*, Muller.	8

Case No.	Name.	No. of Specimens.
54.	*H. jejuna*, Say	6
55.	*H. variabilis*, Draper	9
56.	*H. marginata*, Mueller.	1
57.	*H. pennsylvanica*, Green	60
58.	*H. profunda*, Say	31
59.	*H. sinuata*, Mueller	2
60.	*H. orbiculata*, Ter.	2
61.	*H. strigella*, Draper	12
62.	*H. serpentina*, Ter.	1
63.	*H. strigata*, Mueller	3
64.	*H. variabilis*, Draper	4
65.	*H. dupetithouarsi*, Deshayes	6
66.	*H. clarkii*, Lea	2
67.	*H. devia*, Gould	3
68.	*H. paludosa*, Pf.	4
69.	*H. roemeri*, Pf	3
70.	*H. devia.*	4
71.	*H. kelletti*, Forbes.	4
72.	*H. appressa*, Dehayes	41
73.	*H. clausa*, Say	60
74.	*H. trochoides*, Poiret.	5
75.	*Helix profuga*, Schr	7
76.	*H. caraibbaea*, Winn	10
77.	*H. elegans*, Draper	4
78.	*H. invalida*, C. B. Adams	2
79.	*H. tryoni*, Newcomb	2
80.	*H. memoralis*, Linn	3
81.	*H. similaris*, For	3
82.	*H. reticulata*, Pf	2
83.	*H. pisana*, Mueller	4
84.	*H. splendida*, Draper	1
85.	*H. psammophora*, Lowe	3
86.	*H. isabella*, Ter	3
87.	*H. candidula*, Stud	44
88.	*H. mitchelliana*, Lea	60
89.	*H. ayersiana*, Newcomb	7
90.	*H. straita*, Draper	4
91.	*H. arbutsorum*, Lamarck	4
92.	*H.* (*Triodopsis*) *fallax*, Say	29
93.	*H. obstricta*, Say	7
94.	*H. bermudensis*	3
95.	*H. harfordiana*, Cooper	2
96.	*H. instabilis*, F	3

Case No.	Name.	No. of Specimens.
97.	*H. pyramidata*, Draper	9
98.	*H. extensa*, Pfeiffer	3
99.	*H. redimita*, Binney	10
100.	*Helix sternsiana* Gobb	3
101	*H. physalis*, Benson	3
102.	*H.* (*Stenotrema*) *spinosa*	6
103.	*H. muscarum*, Lea	2
104.	*H. penicellata*, Gould	2
105.	*H. nemoralina*, Fet	6
106.	*H. thymorum*, Alton	7
107.	*H. ramonis*, D. Orbigny	2
108.	*H. similaris*, Ter	7
109.	*H. migratoria*, Pf	1
110.	*H. ramentosa*, Gould	1
111.	*H. nivosa*, Lowe	1
112.	*H. deliberta*, Benson	1
113.	*H. hortensis*, Muller	13
114.	*H. mormonum*, Pf	8
115.	*H. orbiculata*, Ter	2
116.	*H. nickliniana*, Lea	14
117.	*H. picta*, Boon	1
118.	*H. ventrosula*, Pf	4
119.	*H. anomala*, Pf	2
120.	*H. pachygastra*, Gray	2
121.	*H. townsendiana*, Lea	2
122.	*H. caldwellii*, Benson	4
123.	*H. niciensis*, Ter	1
124.	*Helix trochiformis*, Ter	5
125.	*H. pisana*, Muller	5
126.	*H. columbiana*, Lea	5
127.	*H. lycnuchus*, Muller	2
128.	*H. sylvatica*, Draper	4
129.	*H. rectangula*, Pf	7
130.	*H. paraiana*, D. Orb	1
131.	*H. muralis*, Muller	1
132.	*H. diabloensis*, Cooper	3
133.	*H. cubensis*, Pf	3
134.	*H. notata*	1
135.	*H. segestana*, Phillips	1
136.	*H. strangulata*, C. B. Adams	2
137.	*H. clathratula*, Bun	2
138.	*H. hirsuta*, Say	100
139.	*H. monodon*, Rackett	30

Case No.	Name.	No. of Specimens.
140.	*H. sayii*, Binney	10
141.	*H. californiensis*, Lea	2
142.	*H. gobanzii*, Draper	1
143.	*H. perspectiva*, Say	100
144.	*H. personata*, Lamarck	8
145.	*H. albolabris*, Say	2
146.	*H. germana*, Gould	4
147.	*H. stenotrema*, Ter	29
148.	*Helix maxillata*, Gould	3
149.	*H. evardsi*, Bland	5
150.	*H. labrosa*, Bland	3
151.	*H. hirsuta*, Say	10
152.	*H. leptostyla*, Dohru	2
153.	*H. candicans*, Ziegler	15
154.	*H. dentifera*, Binney	3
155.	*H. ambrosia*, Angas	1
156.	*H. bodia*, Ter	2
157.	*H. hemphillii*, Newcomb	2
158.	*H. obvia*, Hartman	7
159.	*H. banksii*, Cumming	1
160.	*H. pandorae*, Forbes	3
161.	*H. downieana*, Bland	1
162.	*H. saleana*, Pf	1
163.	*H. pisano*, Muller	2
164.	*H. inflecta*, Say	37
165.	*H. (Arionta) facta*, Newcomb	9
166.	*H. reticulata*, Pf	2
167.	*H. (Arionta) carpenteri*, Newcomb	2
168.	*H. (Arionta) gabbi*, Newcomb	3
169.	*H. (Arionta) sequoicota*, Cooper	2
170.	*H. (Arionta) refincincta*, Newcomb	2
171.	*H. rugeli*, Shuttleworth	12
172.	*Helix vultuosa*, Gould	5
173.	*H. (Pomalia) aperta*, Boon	3
174.	*H. (Stenotrema) edgariana*, Lea	2
175.	*H. barbigera*, Redfield	3
176.	*H. uvulifera*, Shuttleworth	5
177.	*H. mooreana*, Binney	4
178.	*H. avara*, Say	4
179.	*H. triodontoides*, Bland	4
180.	*H. auriformis*, Bland	5
181.	*H. polygyrella*, Bland	1
182.	*H. troostiana*, Lea	8

Case No.	Name.	No. of Specimens.
183.	*H. fastigans*, Say	4
184.	*H. hazardi*, Bland	9
185.	*H. pustuloides*, Bland	2
186.	*H. cereolus*, Muhlfeldt	11
187.	*H. carpenteriana*, Bland	9
188.	*H. dorfeuilliana*, Lea	4
189.	*H. ventricosus*, Drapernand	2
190.	*H. pustula*, Ferussac.	1
191.	*H. tholus*, Binney	3
192.	*H. acutus*, Brug	7
193.	*H. pulchella*, Muller	150
194.	*H. astericus*, Morse	20
195.	*H. labyrinthica*, Say	30
196.	*H. incrustata*, Bourgh	3
197.	*Helix formosa*, Ter	1
198.	*H. submaritima*, Bourgh	3
199.	*H. fasciata*.	2
200.	*Chilotrema lapicida*, Linn.	6
201.	*Vitrina limpida*, Gould.	18
202.	*V. pfeifferi*, Newcomb.	3
203.	*V. diaphana*, Mueller	8
204.	*V. pellucida*, Mueller	53
205.	*Macrocyclis concava*, Say	18
206.	*Macrocyclis concava*, Say	4
207.	*Macrocyclis concava*, Say	10
208.	*M. sportella*, Gould	5
209.	*M. sportella*, Gould	1
210.	*M. voyana*, Newcomb	4
211.	*Zonites caduca*, Pfe	2
212.	*Z. fuliginosa*, Griffith	8
213.	*Z. inornata*, Say	10
214.	*Z. kopnodes*, Binney	5
215.	*Z. euryomphalus*, Pde	2
216.	*Z. newberryana*, Binney	2
217.	*Z. sculptilis*, Bland	3
218.	*Z. croaticus*, Partsch.	2
219.	*Z. laevigata*, Pfe	3
220.	*Z. suppressa*, Say	3
221.	*Z. edentulus*, Dra	1
222.	*Z. elliottii*, Redfield	8
223.	*Z. gularis*, Say	22
224.	*Zonites (Helix) friabilis*, Binney	40
225.	*Mesodon chilhowensis*, Lewis.	1

Case No.	Name.	No. of Specimens.
226.	*Campylaea foelens, var. achates*, Studer	1
227.	*Fruticicola montana*, Studer	4
228.	*Campylaea intermedia*, Ferrusac	3
229.	*Camphylaea hermesiana*, Pin	2
230.	*C. cingulata*, Studer	3
231.	*C. macrostoma*, Mühlf	1
232.	*C. phalerata*, Ziegler	1
233.	*C. faustina*, Ziegler	1
234.	*C. foelens, var. cisalpina*, Pfe	1
235.	*C. pettita*, Ter	2
236.	*C. schmidtii*, Ziegler	2
237.	*C. planospira*, Lamarck	2
238.	*Triodopsis vannostrandi*, Bld	1
239.	*Macrocyclis vancouverensis*, Lea	5
240.	*M. concava*, Say	4
241.	*Helicina orbiculata*, Say	200
242.	*H. submarginata*, Gray	5
243.	*H. rohri*, Pfe	7
244.	*H. flavescens*, Pease	3
245.	*H. neritella*, Lamarck	12
246.	*H. unda*, Arango	2
247.	*H. occulta*, Say	100
248.	*H. solida*, Pease	8
249.	*Helicina rubicunda*, Pease	2
250.	*H. variabilis*, Wag	3
251.	*H. adamsiana*, Pfe	4
252.	*H. rostrata*, Morse	4
253.	*H. tropica*, Jen	4
254.	*H. sphæroides*, Pfe	5
255.	*H. glabra*, Anthony	11
256.	*H. cinctella*, Schowalter	2
257.	*H. amœna*, Pfe	5
258.	*H. sagraina*, D. Orb	3
259.	*H. flavescens*, Pease	6
260.	*H. miniata*, Lepon	8
261.	*H. costata*, Gray	5
262.	*H. depressa*, Gray	4
263.	*H. regina*, Morse	4
264.	*H. substriata*, Gray	8
265.	*H. mangeriae*, Gray	5
266.	*H. oweniana*, Pfe	6
267.	*H. lyrata*, Pfe	4
268.	*H. jamaicaensis*, Sow	2

Case No.	Name.	No. of Specimens.
269.	*H. aurantia*, Gray	2
270.	*H. tahitensis*, Pease	9
271.	*Hyalana demissa*, Binney	14
272.	*H. indentata*, Say	9
273.	*Hyalina lasmodon*, Phillips	5
274.	*H. interna*, Say	14
275.	*H. ferrea*, Morse	8
276.	*H. minuscula*, Binney	6
277.	*H. chersinella*, Dall	15
278.	*H. conspecta*, Bland	4
279.	*H. binneyana*, Morse	8
280.	*H. gundlachi*, Pfe.	2
281.	*H. significans*, Bland	2
282.	*H. durantii*, Newcomb	4
283.	*H. arborea*, Say	75
284.	*H. virdula*, Menke	5
285.	*H. exigua*, Stimps.	27
286.	*H. viridulad*, Menke	2
287.	*H. limatula*, Ward	15
288	*H. capsella*, Gould	6
289.	*H. fulva*, Draparnaud	60
290.	*H. cerinoidea*, Anthony	2
291.	*H. intertexta*, Binney	8
292.	*H. milium*, Morse	10
293.	*H. multidenta*, Binney	2
294.	*H. ligera*, Say	16
295.	*H. olivetorum*, Her	2
296.	*Patula rupestris*, Draper	50
297.	*P. strigosa*, Gould	4
298.	*Patula ruderata*, Studer	5
299.	*P. rotundata*, Muller	45
300.	*P. pygmaea*, Draper	7
301.	*P. pygmaea*, Draper	12
302.	*Cyclostus seminudus*, Adams	3
303.	*C. jamaicensis*, Ch.	2
304.	*C. saturalis*, Bland	1
305.	*C. dysoni*, Pf.	1
306.	*C. blanchetianum*, Morice	4
307.	*Alcadia palliata*, Ter	2
308.	*A. hollandi*, Adams	2
309.	*A. major*, Gray	5
310.	*Nanina subcircula*, Mousson	1
311.	*Proserpina nitida*, Sow	6

Case No.	Name.	No. of Specimens.
312.	*Alassia willandei*, Adams	2
313.	*Fruticicola unidentata*, Draper.	4
314.	*F. bidens*, Chemitz	6
315.	*F. hispida*, Linneus	21
316.	*F. peregra*, Pan.	5
317.	*F. limbata*, Draper	1
318.	*F. fruticum*, Muller	4
319.	*F. carthusiana*, Muller	4
320.	*F. umbrosa*, Partsch	3
321.	*F. sericea*, Draper	11
322.	*Fruticicolo rufescens*, Pem.	6
323.	*F. villosa*, Draper	7
324.	*F.* (*Monacha*) *incarnata*, Muller	13
325.	*F.* (*Trichia*) *coelata*, Studer.	7
326	*Pentataenia* (*Macularia*) *vermiculata*, Muller	5
327.	*Gonoctoma obvoluta*, Muller	13
328.	Species unidentified	2
329.	Species unidentified	3
330.	Species unidentified	1
331.	*Sayda jayana*, C. B. Adams	1
332.	*Dorcasia berlandieriana*, Moricand	11
333.	*Dermatocera vitera*, Lesson	2
334.	*Leucochroa candidissima*, Drap.	2
335.	*Helicodiscus lineatus*, Say	50
336.	*Cyclophorus wahlbergi*, Benson	2
337.	*Lucida aureola*, Fer	1
338.	*Lucidella granulosa*, Adams	3
339.	*Lucidella undulata*, Pfe.	5
340.	*Lucidella aureola*, Fer	18
341.	*Ortholicus undatas*, Brug	3
342.	*O. zebra*, Muller	3
343.	*Cyclophorus herklozi*, Mast.	1
344.	*Otopoma philippianum*, L. Pef.	5
345.	*Microphysa lansingi*, Bl.	1
346.	*Schasicheila pannucea*, Mor	3
347.	*Trocatella pulchella*, Gray	16
348.	*T. tankervillei*, Gray	[illegible]
349.	*Trocatella josephinia*	2
350.	*Bulimulus multilineatus*, Say	1
351.	*B. dealbatus*, Say	8
352.	*B. exilis*, Brug	14
353.	*B. alternatus*, Say.	2
354.	*B. elongatus*, Barton.	3

Case No.	Name.	No. of Specimens.
355.	*B. scheideanus*, Pfe	19
356.	*Choanopoma pulchrum*, Wood	1
357.	*C. lima*, Adams.	2
358.	*C. fimbriatum*, Sow	7
359.	*Stenogyra decollata*, Linn	3
360.	*S. sublula*, Pfe	2
361.	*S. octona*, Chem.	3
362.	*Glandina turris*, Pfe	2
363.	Species unidentified.	1
364.	*G. decussata*, Deshayes.	1
365.	*G. parallela*, Binney.	3
366.	*G. truncata*, Gme	3
367.	*G. rosea*, Redfield.	2
368.	*G. cordovana*, Pfe	3
369.	*G. texasiana*, Pfe	3
370.	*G. carminensis*, Mor	2
371.	*G. vanuxemensis*, Lea	1
372.	*Helix strigosa* (*var. haydeni*), Gould	1
373.	*H. cumberlandiana*, Lea	4
374.	*Helix idahoensis*, Newcomb	4
375.	*H. cooperi*, Binney	6
376.	*H. striatella*, Anthony	75
377.	*H. espiloca*, Ravenel.	2
378.	*H. febigeri*, Bland	8
379.	*H. introferens*, Bland	2
380.	*H. ventrosula*, Pfe.	2
381.	*H. griseola*, Pfe.	13
382.	*H. hopetonensis*, Shuttleworth	4
383.	*H. divesta*, Gould	4
384.	*H. postelliana*, Bland	3
385.	*H. texasiana*, Moricand	2
386.	*H. auriculata*, Say	5
387.	*H. columbiana*, Lea	5
388.	*H. wheatleyi*, Bland	1
389.	*H. septemvolva*, Say	31
390.	*H. vortex*, Pfe	1
391.	*H. harpa*, Say	4

Specimens in Case No. 5.

UNIONIDAE.

Case No.	Name.	No. of Specimens.
1.	*Unio gibbosus*, Barnes	2
2.	*U. gibbosus*, Barnes	2
3.	*U. crassidens*, Lamark	1
4.	*U. crassidens*, Lamark	1
5.	*U. rectus*, Lamark	1
6.	*U. rectus*, Lamark	2
7.	*U. hopetonensis*, Lea	1
8.	*U. downiei*, Lea	1
9.	*U laevissimus*, Lea	1
10.	*U. cicatricosus*, Say	2
11.	*U. capax*, Green	2
12.	*U. capax*, Green	2
13.	*U. capax*, Green	3
14.	*U. dolabriformis*, Lea	1
15.	*U. silloquoides*, Barnes	1
16.	*U. lugubris*, Say	1
17.	*U. œsopus*, Green	2
18.	*U. œsopus*, Green	7
19.	*U. denus*, Lea	1
20.	*U. obliquus*, Lamark.	2
21.	*U. camelus*, Lea	1
22.	*U. occidens*, Lea	1
23.	*U. gracilis*, Barnes	1
24.	*U. tuberculatus*, Barnes	1
25.	*U. tuberculatus*, Barnes	1
26.	*U. tuberculatus*, Barnes	3
27.	*U. trapezialis*, Say	3
28.	*U. cylindrica*, Say.	2
29.	*U. cylindrica*, Say.	3
30.	*U. trapezoides*, Lea.	1
31.	*U. apiculatus*, Say.	1
32.	*U. plicatus*, Leseuer	1
33.	*U. plicatus*, Leseuer	1
34.	*U. glans*, Lea.	6
35.	*U. atrocostatus*, Les	2
36.	*U. undulata*, Barnes.	4
37.	*U. undulata*, Barnes.	2
38.	*U. undulata*, Barnes.	1
39.	*U. asperrimus*, Lea	2
40.	*U. fragosa*, Lea.	7

Case No.	Name.	No. of Specimens.
41.	*U. irroratus*, Lea	6
42.	*U. irroratus*, Lea, *stegarius*, Rafinesque	3
43.	*U. pustulatus*, Lea	7
44.	*U. pustulatus*, Lea	4
45.	*U. cornutus*, Barnes	5
46.	*U. cornutus*, Barnes	3
47.	*U. metanevrus*, Rafinesque	5
48.	*U. metanevrus*, Rafinesque	6
49.	*U. metanevrus*, Rafinesque	2
50.	*U. zigzag*, Lea	40
51.	*U. rangianus*, Lea.	6
52.	*U. elegans*, Lea.	3
53.	*U. elegans*, Lea	4
54.	*U. lewisii*, Lea	4
55.	*U. kleinianus*, Lea	4
56.	*U. rubiginosus*, Lea	4
57.	*U. fabalis*, Lea	9
58.	*U. arcaeformis*, Lea	4
59.	*U. presostianus*, Lea.	4
60.	*U boykinianus*, Lea	1
61.	*U. favidens*, Benson.	1
62.	*U. acutissimus*, Lea	2
63.	*U. complanatus*	4
64.	*U. fisherianus*, Les	10
65.	*U. carissus*, Say	4
66.	*U. dormas*, Lea.	3
67.	*U. roanokensis*, Lea	1
68.	*U. callinus*, Conrad	2
69.	*U. negatus*, Lea.	2
70.	*U. camptodon*, Say.	2
71.	*U. chattanoogaensis*, Lea	2
72.	*U. subgibbosus*, Lea	1
73.	*U. purradiatus*, Lea	3
74.	*U. asper*, Lea	2
75.	*U. asperatus*, Les	1
76.	*U. orbicualtus*, Hildreth	1
77.	*U. consanguinneus*, Lea	2
78.	*U. plenus*, Lea	1
79.	*U. plenus*, Lea	4
80.	*U. mytholoides*, Raf., *pyramidatus*, Lea	3
81.	*U. jewetti*, Lea	4
82.	*U. conspicuus*, Lea	1
83.	*U. glans*, Lea	4

Case No.	Name.	No. of Specimens.
84.	*U. donaciformis*, Lea.	3
85.	*U. stewardsoni*, Lea	5
86.	*U. forbesianus*, Lea	2
87.	*U. radiosus*, Lea	2
88.	*U. laterostris*, Lea	1
89.	*U. nasutus*, Say	2
90.	*U. pawensis*, Lea	1
91.	*U. pudicus*, Lea	2
92.	*U. cooperianus*, Lea	2
93.	*U. cooperianus*, Lea	3
94.	*U. glebulus*, Say	3
95.	*U. glebulus*, Say	2
96.	*U. subglobatus*, Lea	1
97.	*U. compactus*, Lea. Male	1
98.	*U. compactus*, Lea. Female	1
99.	*U. appressus*, Lea	2
100.	*U. scamnatus*, Morilet	3
101.	*U. lesueurianus*, Lea	2
102.	*U. nullatus*, Lea	1
103.	*U. iris*, Lea	4
104.	*U. favosus*, Lea	2
105.	*U. propinquus*, Lea	4
106.	*U. irden*, Ketz	4
107.	*U. verrucosus*, Barnes	4
108.	*U. verrucosus*, Barnes	3
109.	*U. crassus*, Say	2
110.	*U. consanguineus*, Lea	4
111.	*U. aratus*, Lea	2
112.	*U. varicosus*, Lea	1
113.	*U. constrictus*, Conrad	3
114.	*U. kirtlandianus*, Lea	1
115.	*U. stonensis*, Lea	2
116.	*U. holstonensis*, Lea	2
117.	*U. incrassatus*, Lea	2
118.	*U. rivularis* (?), Cour	3
119.	*U. racensis*, Lea	2
120.	*U. purpuratus*, Lamark	1
121.	*U. monodontus*, Say	1
122.	*U. bourmanus*, Lea	2
123.	*U. ligamentinus*, Lemark	2
124.	*U. ligamentinus*, Lamark	3
125.	*U. subrotundatus*, Lea	6
126.	*U. irwinensis*, Lea	3

Case No.	Name.	No. of Specimens.
127.	*U. corrunculus*, Lea	4
128.	*U. cariosus*, Say	2
129.	*U. ochracianus*, Say	5
130.	*U. tuberosus*, Lea	3
131.	*U. ovatus*, Say	1
132.	*U. callinus*, Conrad	2
133.	*U. auratus*, Swainson	1
134.	*U. bisselianus*, Lea	3
135.	*U. subovatus*, Lea	4
136.	*U. subovatus*, Lea	2
137.	*U. schoolcraftii*, Lea	5
138.	*U. geometricus*, Lea	2
139.	*U. obtusus*, Lea	3
140.	*U. lienosus*, Conrad	3
141.	*U. hepatica*, Lea	2
142.	*U. fatuus*, Lea	1
143.	*U. tertious*, Lea.	4
144.	*U. amicus*, Ziegler	1
145.	*U. tetricus*, Lea	2
146.	*U. fibuloides*, Conrad.	3
147.	*U. salebrosus*, Lea	3
148.	*U. monadontus*, Say	1
149.	*U. pustulosus*, Lea.	8
150.	*U. pustulosus*, Lea.	4
151.	*U. pustulosus*, Lea.	4
152.	*U. camptodon*, Say	6
153.	*U. contiguus*, Lea	3
154.	*U. unbilus*, Lea.	2
155.	*U. viridanus*, Lea	2
156.	*U. sparus*, Lea	2
157.	*U. rutilans*, Lea	3
158.	*U. productus*, Lea	1
159.	*U. jejunus*, Lea.	3
160.	*U. marginalis*, Lea	2
161.	*U. sumatrensis*, Dunker	1
162.	*U. strumosus*, Lea	2
163.	*U. catawbaensis*, Lea.	2
164.	*U. formanianus*, Lea	2
165.	*U. pybasii*, Lea	5
166.	*U. soleniformis*, Lea	5
167.	*U. soleniformis*, Lea	2
168.	*U. retusus*, Lemark	5
169.	*U. mississippiensis*, Clark	2

Case No.	Name.	No. of Specimens.
170.	*U. plexus*, Conrad	8
171.	*U. parvus*, Barnes.	5
172.	*U. pressus*, Lea	6
173.	*U. sublatus*.	4
174.	*U. lapillus*, Say.	3
175.	*U. contiguus*, Lea	2
176.	*U. alatus*, Say	2
177.	*U. vessoi*, Bourguignat.	5
178	*U. sowerbianus*, Lea	1
179.	*U. stapes*, Lea	1
180.	*U. tenuissimus*, Lea	8
181.	*U. merus*, Lea	2
182.	*U. tumidus*, Lea	1
183.	*U. kertlandianus*, Lea	6
184.	*U. anodontoides*, Lea, *teres*, Raf	3
185.	*U. præposterus*, Reg	2
186.	*U. carolinensis*	3
187.	*U. sampsoni*, Lea	3
188.	*U. perplexus*, Lea	3
189.	*U. graniferus*, Lea	2
190.	*U. purpureus*, Lea	2
191.	*U. biangulatus*, Lea	3
192.	*U. cuneatus*, Barnes	1
193.	*U. nasutus*, Say.	4
194.	*U. solidus* Lea	2
195.	*U. margaritifera*, Retzras.	1
196.	*U. securis*, Lea, *lineolatus*, Raf	3
197.	*U. multiradiatus*, Lea	10
198.	*U. triangularis*, Barnes	4
199.	*U. argenteus*, Lea	2
200.	*U. personatus*, Say.	1
201.	*U. planilatens*, Conrad	2
202.	*U. brumbyanus*, Lea.	1
203	*U. veras*, Lea	2
204.	*U. spatulatus*, Lea.	5
205.	*U. riddellii*, Lea	1
206.	*U. sulcatus*, Lea	2
207.	*U. perdix*, Lea	1
208.	*U. phaseolus*, Hildreth	9
209.	*U. phaseolus*, Hildreth	3
210.	*U. phaseolus*, Hildreth	2
211.	*U. ovatus*, Say	3
212.	*U. species*	——

Case No.	Name.	No. of Specimens.
213.	*U. pullatus*, Lea	3
214.	*U. dignatus*, Lea	1
215.	*U. hartmaniana*, Lea	2
216.	*U. dorfeullianus*, Lea	1
217.	*U. acutissimus*, Lea	2
218.	*U. ellipticus*, Sphix	2
219.	*U. capsæformis*, Lea	1
220.	*U. bigbyensis*, Lea.	2
221.	*U. elliotti*, Lea	1
222.	*U. concolor*, Lea	2
223.	*U. intermedius*, Conrad	3
224.	*U. porphyrius*, Lea	1
225.	*U. strigosus*, Lea	3
226.	*U. lugubris*, Say, *ater*, Lea	1
227.	*U. luteolus*, Lamark	5
228.	*U. luteolus*, Lamark	1
229.	*U. parvus*, Barnes.	2
230.	*U. subtentus*, Say	1
231.	*U. nux*, Lea	2
232.	*U. parvulus*, Lea	2
233.	*U. osbeckii*, Phili	5
234.	*U. nigerrimus*, Lea	3
235.	*U. paulas*, Lea	3
236.	*U. fallax*, Lea	2
237.	*U. McNealii*, Lea	3
238.	*U. conradianus*, Lea	2
239.	*U. humidus*, Ketz	18
240.	*U. pressus*, Lea	4
241.	*U. confertus*, Lea	4
242.	*U. prasinus*, Conrad, *schoolcraftensis*, Lea	3
243.	*U. furvus*, Lea	1
244.	*U. piculus*, Lea	1
245.	*U. troosti*, Lea	2
246.	*U. datus*, Lea	2
247.	*U. securiformis*, Conrad, *infucatus*, Lea	5
248.	*U. grayii*, Lea	1
249.	*U. heterodon*, Lea	1
250.	*U. ophaensis*, Lea	2
251.	*U. stabilis*, Lea	2
252.	*U. batavus*	5
253.	*U. vellum*, Say	1
254.	*U. shepardianus*, Lea	3
255.	*U. gracilis*, Barnes	2

Case No.	Name.	No. of Specimens.
256.	*U. gracilis*, Barnes	2
257.	*U. muhtfeldianus*, Lea	1
258.	*U. edgarianus*, Lea	2
259.	*U. congarus*, Lea	2
260.	*U. distans*, Anthony	1
261.	*U. medius*, Lea	2
262.	*U. rubidus*, Lea	2
263.	*U. lyonii*, Lea	1
264.	*U. prattii*, Lea	2
265.	*U. subellipsis*, Lea	
266.	*U. fuscatus*, Lea	3
267.	*U. simus*, Lea	2
268.	*U. andersoni*, Lea	2
269.	*U. subtentus*, Say	4
270.	*U. dehiscens*, Say	7
271.	*U. coccineus*, Hildreth	2
272.	*U. lincecumii*, Lea	1
273.	*U. newcombianus*, Lea	1
274.	*U. striatus*, Lea	1
275.	*U. curatus*, Lea	2
276.	*U. obesus*, Lea	2
277.	*U. intercedus*, Lea	2
278.	*U rubellinus*, Lea	2
279.	*U. chattanoogaensis*, Lea	2
280.	*U. hidianus*, Lea	1
281.	*U. nashvillensis*, Lea	4
282.	*U. tumescens*, Lea	1
283.	*U. dariensis*, Lea	2
284.	*U. clavus*, Lamark	10
285.	*U. clavus*, Lamark	10
286.	*U. caperatus*, Lea	2
287.	*U. chuni*, Lea	2
288.	*U. elliottii*, Lea	2
289.	*U. sphaericus*, Lea	2
290.	*U. thorntonii*, Lea	2
291.	*U. cactatus*, Conrad	3
292.	*U. lugubris*, Lea	3
293.	*U. instructus*, Lea	1
294.	*U. clinchensis*, Lea	1
295.	*U. ridibundus*, Say, *sulcatus*, Lea	4
296.	*U. neusensis*, Lea	2
297.	*U. capsœformis*, Lea	2
298.	*U. alatus*, Say	4

Case No.	Name.	No. of Specimens.
299.	*U. downeii*, Lea	3
300.	*U. distans*	6
301.	*U. batavus*, Lea	3
302.	*U. harleyanus*, Lea	2
303.	*U. gibber*, Lea	1
304.	*U. interventus*, Lea	2
305.	*U. haysianus*, Lea	1
306.	*U. subrotundus*, Lea	1
307.	*U. penitus*, Conrad	3
308.	*U. buckleyi*, Lea	3
309.	*U. lawii*, Lea	2
310.	*U. striatulus*, Lea	2
311.	*U. instructus*, Lea	1
312.	*U. favosus*, Lea	2
313.	*U. arctatus*, Conrad	1
314.	*U. siliquoideus*, Barnes	2
315.	*U. delphinus*, Graner	1
316.	*U. excavatus*, Lea	3
317.	*U. dehiscens*, Say	8
318.	*U. schowalterii*, Lea	2
319.	*U. lavirostris*, Benson	1
320.	*U. mississippiensis*, Conrad	1
321.	*U. granulatus*, Lea	5
322.	*U. infuscus*, Lea	3
323.	*U. canadensis*.	2
324.	*U. brevidens*, Lea. Female	2
325.	*U. brevidens*, Lea. Male	2
326.	*U. wardii*, Lea	2
327.	*U. hydianus*, Lea	4
328.	*U. tappanianus*, Lea	18
329.	*U. ebenus*, Lea	1
330.	*U. ebenus*, Lea	2
331.	*U. nigerrimus*, Lea	6
332.	*U. lanceolatus*, Lea	3
333.	*U. rostratus*, Ziegler	2
334.	*U. patulus*, Lea	3
335.	*U. cumberlandicus*, Lea	3
336.	*U. dolabilloides*, Lea	2
337.	*U. lachrymosus*, Lea	1
338.	*U. tenebricus*, Lea	3
339.	*U. subglobosus*, Lea	2
340.	*U. subangulatus*, Lea	9
341.	*U. iris*, Lea	12

Case No.	Name.	No. of Specimens.
342.	*U. blandianus*, Lea	2
343.	*U. percoarctatus*, Lea	2
344.	*U. conradicus*, Lamark	4
345.	*U. sayii*, Conrad ; *campotdon*, Say	1
346.	*U. splendidus*.	1
347.	*U. roanokensis*, Lea	1
348.	*U. inflatus*, Say	1
349.	*U. straminius*, Conrad	1
350.	*U. globatus*, Lea	2
351.	U. species	1
352.	*U. multiplicatus*, Lea	1
353.	*U. multiplicatus*, Lea	2
354.	*U. multiplicatus*, Lea	1
355.	*U. multiplicatus*, Lea	1
356.	U. species	1
357.	U. species	1
358.	*U. torsus*, Rafinesque	5
359.	*U. pilaris*, Lea	1
360.	*U. lens*, Lea	3
361.	*U. lens*, Lea	3
362.	*U. obliquus*, Lamark.	6
363.	*U. trigonus*, Lea	1
364.	*U. ziegleranus*, Lea	1
365.	*U. camelus*, Lea	2
366.	*U. radiatus*.	10
367.	*U. calceola*, Lee.	5
368.	*U. pictorum*, Ketz.	3
369.	*U. occultus*, Lea.	1
370.	*U. laevissimus*, Lea	6
371.	*U. subflavus*, Lea	2
372.	*U. vollatus*, Lea.	1
373.	*U. forsheyi*, Lea	2

Species in Case No. 4.

UNIONIDAE.

Name	No. of Species.
Alasmodonta angesa, Barnes	1
A. calceola, Lea	2
A. fabula var. curreyana, Lea.	2
A. obscura, Anthony	1
A. undulata, Say	3
Anodonta callosa, Held	2

	No. of Specimns.
A. cellensis, Pfeif	2
A. compacta, Zelchor	2
A. companiana, Lea	2
A. complanata Var. minor, Cassel	2
A. confragosa, Say	7
A. cygnea, Lamarck	2
A. dariensis, Lea	1
A. decora, Lea	2
A edentata, Say	6
A. ferussaciana, Lea	1
A. fluviatilis, Dill.	2
A. footiana, Lea	1
A. gibbosa, Say	2
A glabra, Zeigler	2
A. grandis, Say	4
A. imbecilis, Say	10
A. implicata, Say	1
A. lacustris, Lea	6
A. lewisii, Lea	2
A. mericandi, Lea	1
A. nuttellianus, Lea	2
A. oregonensis, Lea	4
A. ovata, Lea	5
A. papyracea, Anthony	2
A. pavonia, Lea	2
A. piscinalis, Nillson	4
A. plana, Lea	1
A. rostrata, Kokeil	2
A. salamonia, Say	4
A. schowalterii, Lea	4
A. subcylindricus, Lea	5
A. suborbiculata, Say	4
A. trapezialis, Lea	3
A. tryoni, Lea	4
A. undulata, Say	3
A. vesqucata, Bourguignat	1
A. wahlamatensis, Lea	2
A. wardiana, Lea	8
Margaritana complanata, Barnes	3
M. dehiscens, Say	3
M. deltoides, Lea	5
M. falcata, Gould	3
M. hildrethiana, Lea	15

	No. of Specimens.
M. holstonia, Lea	4
M. marginata, Say	17
M. minor, Lea	4
M. rugosa, Barnes	4
M. triangulata, Lea	2
M. truncata, Say	5
M. undulata, Say	3
M. confragosa, Say	6

LIST OF DUPLICATE SHELLS.

Alasmodonta rugosa, Barnes.	2
Angitrema nupera, Say	223
Anodonta cellensis, Pfeifer	1
A. decora, Lea	64
A. edentula, Lea	38
A. imbecilis, Say	47
A. gibbosa, Lea.	3
A. grandis, Say.	45
A. lacustris, Lea	8
A. ovata, Lea	7
A. subcylindracea, Lea.	10
A. suborbiculata, Say	10
A. wardiana, Lea.	39
Arca incongrua, Say.	6
Artemis concentrica, Lamarck.	4
Cardium maculosum	10
Cassiduria sp. (?)	2
Cyprea arabicula	3
Goniabasis depygis, Say	164
Helicina occulta, Say	51
H. orbiculata, Say	273
Helix alternata, Say	40
H. appressa, Say	342
Helix aspera, Lea.	1
H. clausa, Say	718
H. elevata, Say.	434
H. exoleta, Binney	738
H. (*Triodopsis*) *fallax*, Say	20
H. (*Stenotrema*) *fraternus*, Say	5
H. (*Zonites*) *friabilis*, Binney,	907
H. hirsuta, Say.	99
H. leaii, Ward.	4

	No. of Specimens.
H. lineata, Say	100
H. mitchelliana, Lea	163
H. monodon, Rackett	26
H. multilineata, Say	867
H. palliata, Say	539
H. pennsylvanica, Green	669
H. perspectiva, Say	166
H. profunda, Say	148
H. solitaria, Say	343
H. thyroides, Say	279
H. tridentata, Say	97
Limnea ampla, Mighels	4
L. columella, Say	18
L. stagnalis, Lamarck	580
Margaritana complanata, Lea	40
M. confragosa, Say	78
Margaritana rugosa, Lea	13
M. truncata, Say	162
Melania virginica, Say	566
M. obesa, Lewis	12
M. ponderosa, Say	4
Monocondyloea mardiensis, Lea	1
Neritina cummingianus, Res	28
Pholas florida	1
Physa heterostrophia, Binney	52
Pinna seminuda	2
Planorbis bicarinatus, Say	109
Pomus depressa, Say	5
Pyrula canaliculata	2
P. carica	3
P. perversa, Say	2
Strombus, sp. (?)	2
Trypanostoma alveare, Conrad	520
T. canaliculatum, Say	651
T. conicum, Say	40
T. curicum, Say	120
T. foremanni, Lea	40
T. gradatum, Anthony	8
T. incurvum, Lea	5
T. monoliferum, Say	457
T. nobilis, Lea	7
Trypanostoma undulatum, Say	360
Unio æsopus, Green	19

	No. of Specimens.
U. alatus, Say	68
U. anodontoides, Lea	73
U. asperimus, Lea	14
U. batavus, Lea	24
U. brevidens, Lea	2
U. camptodon, Say	18
U. capax, Green	82
U. cariosus, Say	4
U. cicatricosus, Say	4
U. circularis, Lea.	3
U. clavus, Lamarck	65
U. coccineus, Lea	21
U. complanatus, Soland	38
U. cooperianus, Lea	19
U. crassus, Say.	2
U. cornutus, Barnes	70
U. cuneatus, Barnes.	5
U. cylindricus, Say	24
U. dolabriformis, Lea	4
U. dromas, Lea.	5
U. ebenus, Lea	7
U. elegans, Lea.	32
U. ellipsis, Lea.	54
Unio fisherianus, Lea	17
U. fragosus, Lea	11
U. gibbosus, Barnes	52
U. glebulus, Say	4
U. globosus, Barnes	12
U. gracilis, Barnes	2
U. iris, Lea	24
U. irroratus, Lea	74
U. lachrymosus, Lea.	5
U. laevissimus, Lea	18
U. lens, Lea	90
U. lienosus, Conrad	2
U. ligamentinus, Lamarck	16
U. lugubris, Say	2
U. luteolus, Lamarck	195
U. margaritifera, Retzius	12
U. metanevrus, Refinesque	70
U. multiplicatus, Lea	38
U. multiradiatus, Lea	159
U. nasutus, Say	10

	No. of Specimens.
U. nigerimus, Lea	1
U. obliquus, Lamarck	20
U. obtusus, Lea	1
U. ochraceus, Say	4
Unio occidens, Say	5
U. orbiculatus, Hildreth	1
U. ovatus, Say	11
U. parvus, Barnes	39
U. perplexus, Lea	10
U. phaseolus, Lea	53
U. plenus, Lea	30
U. plicatus, Leseuer	44
U. purpureus, Say	18
U purpuratus, Lamarck	6
U. pusillus, Lea	70
U. pustulatus, Lea	35
U pyramidatus, Lea	63
U. radiatus, Lea	15
U. rangianus, Lea	51
U. rectus, Lamarck	37
U. rubiginosus, Lea	47
U. sampsoni, Lea	11
U. securis, Lea.	76
U. silliquoideus, Barnes	1
U. soleniformis, Lea	43
U. solidus, Lea.	4
U. strumosus, Lea	1
U. subovatus, Lea	6
U. subrotundus, Lea	15
Unio tappanianus, Lea	7
U. tenuissimus, Lea	12
U. torsus, Raf	63
U. trapezoides, Lea	2
U. triangularis, Barnes	16
U. tuberculatus, Barnes	——
U. tumidus, Lea	22
U. undulatus, Barnes	7
Unidentified.	74
U. verrucosus, Barnes	34
U. wardi, Lea	7
U. yadkinensis, Lea	2
U. Zigzag, Lea.	210
Vivipara contactoides, Binney	14

INDIANA BATTLE FLAGS.

The battle flags of Indiana, formerly in the custody of the State Librarian, have, by act of the General Assembly, been transferred to the custody of the State Geologist. Suitable cases have been prepared for them in the rooms of the Geological Museum, and they are now classified and arranged, and on exhibition. They have been placed here that they may be permanently preserved. As they are, battle-scarred and worn, and yellow with age, they are too delicate to handle, and are wholly unfit for use. The law strictly prohibits the removal of any of them from the Museum, and makes it unlawful for the State Geologist to loan any of them for any purpose, except such as he may deem sufficiently preserved to be used at the dedication of the Soldiers' Monument.

It was through the influence of the Grand Army of the Republic that they were transferred to this department for safe keeping, and it was through the contributions of the Grand Army that the cases were originally made for the preservation of the flags, but the General Assembly later on appropriated the money to reimburse the contributors, and now the flags are safely cared for and will be duly preserved.

The following is a complete list of all the flags transferred to this department:

List of Flags in Indiana Museum.

5th Regiment	1 flag
6th Regiment	6 flags.
8th Regiment	3 flags.
9th Regiment	3 flags.
11th Regiment	1 flag.
12th Regiment	3 flags.
13th Regiment	4 flags.
14th Regiment	3 flags.
15th Regiment	5 flags.
16th Regiment	3 flags.
17th Mounted Infantry	2 flags.
18th Regiment	3 flags.

19th Regiment	6 flags.	
20th Regiment	5 flags.	1 guidon.
21st Regiment	3 flags.	
22nd Regiment	1 flag.	
23rd Regiment	4 flags.	
24th Regiment	2 flags.	
25th Regiment	5 flags.	
26th Regiment	2 flags.	
27th Regiment	2 flags.	
28th Regiment	2 flags.	
29th Regiment	2 flags.	
30th Regiment	4 flags.	
31st Regiment	4 flags.	
32nd Regiment	3 flags.	
33rd Regiment	2 flags.	
34th Regiment	2 flags.	
35th Regiment	1 flag.	
36th Regiment	2 flags.	
37th Regiment	2 flags.	
38th Regiment	3 flags.	
39th Regiment	3 flags.	
40th Regiment	3 flags.	
42nd Regiment	3 flags.	
43rd Regiment	2 flags.	
46th Regiment	1 flag.	
47th Regiment	6 flags.	
48th Regiment	2 flags.	
49th Regiment	2 flags.	
51st Regiment	4 flags.	
52nd Regiment	4 flags.	
54th Regiment	2 flags.	
57th Regiment	3 flags.	
58th Regiment	3 flags.	
59th Regiment	1 flag.	
60th Regiment	3 flags.	
61st Regiment	1 flag.	
63rd Regiment	3 flags.	
64th Regiment	1 flag.	
65th Regiment	2 flags.	
66th Regiment	1 flag.	1 camp marker.
67th Regiment	4 flags.	
68th Regiment	5 flags.	1 guidon.
69th Regiment	2 flags.	
70th Regiment	4 flags.	

71st Regiment	4 flags.	
72nd Regiment	2 flags.	
73rd Regiment	2 flags.	
74th Regiment	1 flag.	
75th Regiment	5 flags.	
77th Regiment	2 flags.	
80th Regiment	3 flags.	
81st Regiment	2 flags.	
83rd Regiment	5 flags.	
84th Regiment	2 flags.	
86th Regiment	2 flags.	
87th Regiment	1 flag.	
88th Regiment	1 flag.	
89th Regiment	3 flags.	
91st Regiment	4 flags	
97th Regiment	2 flags.	1 camp marker.
99th Regiment	3 flags.	
100th Regiment	4 flags.	
101st Regiment	1 flag.	
120th Regiment	2 flags.	
123rd Regiment	2 flags.	
124th Regiment	1 flag.	
128th Regiment	1 flag.	
129th Regiment	1 flag.	
130th Regiment	1 flag.	
132nd Regiment	2 flags.	
140th Regiment	1 flag.	
141st Regiment	1 flag.	
142d Regiment	2 flags.	
143d Regiment	1 flag.	
144th Regiment	2 flags.	
145th Regiment	2 flags.	
147th Regiment	1 flag.	
148th Regiment	1 flag.	
149th Regiment	2 flags.	
152d Regiment	1 flag.	
153d Regiment	2 flags.	
160th Regiment	1 flag.	